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ABSTRACT

This teacher resource manual has been developed to assist classroom teachers in implementing the Integrated Occupational Science program for grades 8 and 9. The first chapter of this manual gives an introduction including resources, scope and sequence, facilities and equipment, and safety in the science classroom. The next two chapters describe the overviews and instructional strategies of the grade 8 and 9 themes. The themes developed for each grade level are classified as understanding our environment, using materials and products, technology at work, and life forms and changes. The last chapter discusses: (1) the nature of science; (2) the relationship between science and technology; (3) the role of science and technology in society; (4) communication skills; and (5) evaluation. For each topic the model, suggestions, and resources are provided. Lists 14 references. (YP)

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INTEGRATED OCCUPATIONAL PROGRAM

Teacher Resource Manual

ED313236

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SCIENCE 8 AND 9

INTERIM - 1989

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Teacher Resource Manual

Science 8 and 9

INTERIM – 1989

NOTE: This publication is a service document. The advice and direction offered is suggested only. Consult the Program of Studies/Curriculum Guide to identify the prescriptive contents of the Integrated Occupational Science Program for Grades 8 and 9.

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INTRODUCTION

This *Teacher Resource Manual* has been developed to assist classroom teachers to implement the Integrated Occupational Science 8 and 9 program. This manual provides:

- further information about the goals and objectives of the curriculum
- thematic contexts for the delivery of prescribed concepts, skills and attitudes
- suggestions for planning and implementing the program
  - instructional strategies
  - sequenced activities
  - a correlation of strategies and activities to learning resources
- suggestions for relating science instruction to essential life skills and other applications across the curriculum
- suggestions for utilizing community resources in delivering the science program
- strategies for developing an understanding of science and technology and their role in society
- strategies for organizing thought and action when performing scientific inquiry, solving technological problems and making responsible decisions
- strategies for developing thinking and communicating skills
- suggestions for evaluating student progress.

Teachers are encouraged to use this manual as a practical planning and instructional tool. The binder format was chosen to enable teachers to add strategies, samples of student work and other activities that have proven effective through experience.

During cooperative planning sessions, pages in the manual may be easily removed and shared with other Integrated Occupational Program teachers. This exchange will heighten teacher sensitivity to the content of other subject areas, and provide additional opportunities for students to relate science competencies to applications in real life, the practical arts and other academic disciplines.

ORGANIZATION OF THE TEACHER RESOURCE MANUAL

This manual has been organized to provide ready access to both thematic units of instruction and generic strategies for developing essential concepts, skills and attitudes in science.

THEMES

Thematic units of instruction for Grade 8 and Grade 9 have been placed at the beginning of the manual. The chart below provides an overview of the themes developed at each grade level. Study of the topics outlined in these themes will ensure coverage of the required component.

	GRADE EIGHT	GRADE NINE
Theme A UNDERSTANDING OUR ENVIRONMENT	INTERACTING WITH OUR ENVIRONMENT	MONITORING THE LOCAL ENVIRONMENT
Theme B USING MATERIALS AND PRODUCTS	WORKING WITH SOLUTIONS	USING CHEMICAL PRODUCTS
Theme C TECHNOLOGY AT WORK	USING ENERGY AND MACHINES	ELECTRICAL SYSTEMS IN THE HOME
Theme D LIFE FORMS AND CHANGES	GROWING PLANTS	DIVERSITY IN LIVING THINGS

GENERIC STRATEGIES

Generic strategies that may be effective in developing essential concepts, skills and attitudes have been placed immediately following the themes. These strategies can be used to provide focussed instruction at appropriate times within each theme. Components of instruction that are supported by the generic strategies provided in this manual include:

- The Nature of Science
- The Relationship Between Science and Technology
- The Role of Science and Technology in Society
- Communication Skills
- Evaluation.

Teachers are encouraged to reference these strategies as they plan activities within each theme of the program.

USE OF THE TEACHER RESOURCE MANUAL

It is recommended that THEMES provide the vehicle for instruction in Grade 8 and Grade 9. Activities suggested within each theme will direct teachers to GENERIC STRATEGIES that are useful in developing an:

- understanding of the nature of science
- awareness of the relationships among science, technology and society
- ability to use communication skills in science.

The following example illustrates how generic strategies have been integrated with themes developed in this manual.

- Turn to the first Grade 8 theme, **Interacting With Our Environment**. Notice that within the introduction to this theme, teachers are encouraged to reference generic strategies on:
  - The Nature of Science
  - The Role of Science and Technology in Society
  - Communication Skills
  - Evaluation.

- Locate the "Suggested Activities" that correspond to the first learning objective (i.e., **recognizes that living things interact with other living and non-living parts of the environment**). The following activities make reference to the use of generic strategies:
  (2) Choose an organism from the local environment. Identify all the biotic and abiotic factors that are part of this organism's environment. Classify each factor as biotic or abiotic. Strategies that may assist students to develop classification skills are provided in The Nature of Science, "Processing Data".
  (3) Observe an established aquarium or terrarium. Identify biotic and abiotic factors in this environment, and the interactions that occur between these factors. Attribute guides provide an effective means of structuring student observations. A sample attribute guide has been provided in The Nature of Science, "Gathering Data".

- Locate the "Suggested Activities" that correspond to the second learning objective (i.e., **identifies interactions that occur among living organisms in the local environment**). These activities encourage teachers to reference additional generic strategies:
  (3) Investigate the interactions that occur between living and non-living organisms in a farm environment. Discuss these interactions with a farmer. Prepare a report that synthesizes the information gathered,using strategies provided in Communication Skills, "Making Summaries".
  (6) Conduct a debate: "Grass Depends on People" vs "People Depend on Grass". Structure the debate using suggestions provided in Communication Skills, "Strategies for Discussing and Debating".

Teachers are encouraged to examine each theme and its corresponding activities and learning resources well in advance of instruction. The activities and suggestions provided within each theme are numerous. **Advance planning should include a synthesis of effective strategies from the teacher's repertoire of personal experience together with suggestions in this manual considered most appropriate to students' needs.**

LEARNING RESOURCES FOR I.O.P. SCIENCE 8 AND 9

STUDENT RESOURCES

BASIC LEARNING RESOURCES

It is anticipated that the learning resources listed below will meet the majority of the goals and objectives identified in this curriculum (authorization pending).

McFadden, Charles, et al. *Science Plus Technology and Society 8*. Toronto, Ontario: Harcourt Brace Jovanovich, Canada, publication anticipated in 1990.

McFadden, Charles, et al. *Science Plus Technology and Society 9*. Toronto, Ontario: Harcourt Brace Jovanovich, Canada, publication anticipated in 1990.

Science Plus Technology and Society 8/9 will provide for the development of concepts, skills and attitudes identified in the Grade 8 and Grade 9 Program of Studies/Curriculum Guide. These learning resources will be available in manuscript form throughout the 1989/90 school year. A final print of each learning resource is scheduled for the summer of 1990.

TEACHER RESOURCES

RECOMMENDED LEARNING RESOURCES

Teacher resources designed to support instructional use of the basic learning resources include:

McFadden, Charles, et al. *Science Plus Technology and Society 8 Teacher's Resource Book*. Toronto, Ontario: Harcourt Brace Jovanovich, Canada, publication anticipated in 1990.

McFadden, Charles, et al. *Science Plus Technology and Society 9 Teacher's Resource Book*. Toronto, Ontario: Harcourt Brace Jovanovich, Canada, publication anticipated in 1990.

The teacher manuals for *Science Plus Technology and Society 8/9* include lesson objectives, instructional methods and evaluation strategies that relate to each theme identified in the Grade 8 and Grade 9 programs. These manuals are useful to anyone using the student resources listed above.

TECHNOLOGY AND MEDIA

An annotated list of computer software that may be useful in supporting curriculum objectives is provided in Alberta Education's catalogue of *Computer Courseware Evaluations* (Curriculum Support Branch, Student Programs and Evaluation Division, Alberta Education, 1986) and yearly supplements.

Course delivery may be enhanced through the use of various kits, films, videotapes and brochures that support specific goals and objectives of the science program. Teachers may wish to use local media services, libraries and government agencies in obtaining audio and visual materials appropriate to the science program.

REGIONAL RESOURCE LIBRARIES

Films and videos are available for loan through the five centres listed below. In some instances, computer software is also loaned. Catalogues of holdings are available upon request.

Zone I

Peace River Regional
c/o Peace River School District No. 10
P.O. Box 988
Peace River, Alberta
T0H 2X0
Telephone: 624-3187

Zone II and III

Central Alberta Media Service
c/o Sherwood Park Catholic School District
2017 Brentwood Boulevard
Sherwood Park, Alberta
T8A 0X2
Telephone: 464-5540

Zone IV

Alberta Central Regional Education Services
County of Lacombe No. 14
Bag Service 108
Lacombe, Alberta
T0C 1S0
Telephone: 782-6601

Zone V

South Central Alberta Film Federation
County of Wheatland No. 16
Box 90
Strathmore, Alberta
T0J 3H0
Telephone: 934-5028

Zone VI

Southern Alberta Regional Film Centre
c/o McNally School
P.O. Box 845
Lethbridge, Alberta
T1J 3Z8
Telephone: 320-7807

ACCESS NETWORK

ACCESS offers a variety of resources and services to teachers. For a nominal dubbing and tape fee, teachers may have ACCESS audio and video library tapes copied. ACCESS also offers a service called "Night Owl Dubbing". This allows educators to tape late night educational programs directly from their own televisions.

ACCESS publishes both an *Audio-Visual Catalogue* and a comprehensive schedule of programming, available on request.

For additional information, contact ACCESS NETWORK, Media Resource Centre, 295 Midpark Way SE, Calgary, Alberta, T2X 2A8 (from outside of Calgary, telephone toll free, 1-800-352-8293; in Calgary, telephone 256-1100).

ADDITIONAL SUPPORT MATERIALS

The following learning resources have been identified as potentially useful for the Integrated Occupational Science program. These materials have not been evaluated by Alberta Education and their listing is not to be construed as an explicit or implicit departmental approval for use. The list is provided as a service only to assist local jurisdictions in identifying potentially useful learning resources. The responsibility of evaluating these resources prior to selection rests with the local jurisdiction.

Rosen, Seymour. *Science Workshop Series*. Scarborough, Ontario: Globe/Modern Curriculum Press, 1983.

Text-Workbooks:
- *Biology Workshop 1*, Understanding Living Things
- *Biology Workshop 3*, Understanding Reproduction
- *Chemistry Workshop 1*, Understanding Matter
- *Chemistry Workshop 2*, Understanding Mixtures
- *Physics Workshop 1*, Understanding Energy and Forces
- *Physics Workshop 2*, Understanding Magnetism, Heat and Electricity

SCOPE AND SEQUENCE

The scope and sequence chart provided on the following pages identifies the concepts, processes, skills and attitudes of science that are developmentally addressed throughout Grade 8 and Grade 9. In recognizing that students differ in the rate at which they learn, this chart is intended to assist teachers in:

- assessing present levels of student performance
- diagnosing particular areas of skill deficiency
- sequencing instruction in a manner that will suit individual needs and growth patterns.

In using the scope and sequence, it should be noted that:

- process, skill and attitude are **developmental** through Grades 8 and 9 (i.e., the spiral approach). **Students will reinforce and extend the processes, skills and attitudes developed in Grade 8 through more sophisticated and complex applications at the Grade 9 level.**
- concepts developed at the Grade 8 level are in most cases **discrete** from concepts developed at the Grade 9 level. Effort has been made to apportion concepts throughout Grade 8 and Grade 9 on the basis of their cognitive demand.
- **the concepts, processes, skills and attitudes are interdependent and are not meant to be developed in isolation.** Although some content may be mastered more effectively through discrete instruction, this approach is not advocated as a primary focus of instruction. The thematic structure permits a holistic view of instruction through the linking of strategies and skills.

Teachers may also wish to examine the scope and sequence chart for the senior high school science program (Science 16 and 26). An understanding of the developmental progression of concepts, process and skill occurring beyond Grade 9 will facilitate articulation between the junior high and senior high school science programs.

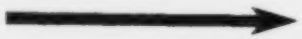
THE NATURE OF SCIENCE

GRADE 8	GRADE 9
Demonstrates an understanding of the nature of science. Recognizes that: • science is a disciplined way to develop explanations for the events and objects of the natural world • science is comprised not only of an accumulated body of knowledge, but also of the processes by which that knowledge is developed • scientific knowledge is based on observation and experimentation • scientific knowledge is not certain, but, rather, it is based on theory which is subject to revision as additional evidence accumulates.	Demonstrates an understanding of the nature of science in increasingly abstract settings.
Displays attitudes appropriate to the process of scientific inquiry: • concern for accuracy and supporting evidence • honesty and completeness in reporting/evaluating evidence • open-mindedness in considering alternative ideas/interpretations • critical mindedness in evaluating inferences/conclusions.	Displays attitudes appropriate to the process of scientific inquiry in an increasingly consistent manner.
Uses appropriate strategies and skills to conduct scientific inquiry: • formulates questions – recognizes patterns/discrepant events – formulates relevant questions about relationships • defines problems – identifies factors relevant to a problem – defines the problem in a form suitable for investigation • proposes ideas – generates ideas about possible relationships – makes predictions based on observations/existing data – formulates hypotheses to explain existing data	Uses appropriate strategies and skills to conduct scientific inquiry in increasingly complex situations.

THE NATURE OF SCIENCE (cont'd)

GRADE 8	GRADE 9
• designs experiments – plans appropriate procedures for testing predictions/hypotheses – identifies kinds of observations/ measurements that might be used – identifies and controls variables – selects appropriate materials/ apparatus • gathers data – makes observations through direct use of the senses – uses specialized observation tools – uses appropriate measuring tools/units/ procedures – makes estimates – records data that has been gathered accurately – prepares drawings of objects/ materials investigated • processes data – organizes data by comparing/ ordering/classifying/calculating – identifies qualitative as well as quantitative differences – summarizes/displays data using simple charts and graphs – identifies patterns/trends • interprets data – infers relationships – identifies cause and effect – generates appropriate explanations based on data that has been gathered – creates models/analogies to explain ideas – evaluates hypotheses in light of data gathered – applies discovered knowledge • evaluates the process – assesses procedures/thought processes used – considers adequacy of data in supporting inferences made • identifies further investigation – seeks further evidence – formulates additional questions – defines new problems.	Uses appropriate strategies and skills to conduct scientific inquiry in increasingly complex situations

SCIENCE AND TECHNOLOGY

GRADE 8	GRADE 9
Demonstrates an understanding of the relationship between science and technology. Recognizes: • that technology is concerned with the solution of practical problems • basic scientific principles associated with the operation of familiar technologies • that science can be used to advance technology and that technology can be used to advance science • various technologies as they are used in practical situations.	Demonstrates an understanding of the relationship between science and technology in increasingly abstract settings.
Displays attitudes appropriate to the process of solving technological problems: • confidence in personal ability to solve practical problems • initiative and perseverance • respect for alternative strategies that might be used in solving problems • appreciates efficiency and design in technological systems.	Displays attitudes appropriate to the process of solving technological problems in an increasingly consistent manner. 
Uses appropriate strategies and skills to solve technological problems: • understands the problem – asks questions – identifies relationships – proposes ideas • develops and carries out a plan – generates/selects alternatives – builds the product/design – tests and troubleshoots the product/design • reviews and applies the results of problem solving – evaluates the process used to solve the problem – evaluates the product in terms of effectiveness and efficiency.	Uses appropriate strategies and skills to solve technological problems in increasingly complex situations.

SCIENCE AND TECHNOLOGY IN SOCIETY

GRADE 8	GRADE 9
Demonstrates an understanding of the role of science and technology in society. Recognizes: • the impact of science and technology on lifestyle, occupational choice, environment and welfare • how personal and societal needs/attitudes influence science and technology • that often the products of science and technology are accepted and used by society before the full extent of benefits and problems resulting from their use can be fully known • the need for "trade-offs" in order to find workable solutions to problems involving science and technology in society • appropriate strategies for making responsible decisions about the use of science and technology in society	Demonstrates an understanding of the role of science and technology in increasingly abstract settings.
Displays attitudes appropriate to the process of making responsible decisions in society: • appreciation of the beauty and complexity of living things • awareness of the interdependence of life forms • awareness of the need for resource conservation • respect for the perspectives and viewpoints of others.	Displays attitudes appropriate to the process of making responsible decisions in an increasingly consistent manner.
Uses appropriate strategies and skills to make responsible decisions about the use of science and technology in society: • understands the problem – identifies the problem – interprets relationships – proposes ideas and alternatives • develops and carries out a plan – researches factual information – researches different perspectives – reflects and decides – makes decisions and takes action • reviews and applies results – evaluates the decision-making process – evaluates the long-term/short-term effects of decisions made and actions taken.	Uses appropriate strategies and skills to make responsible decisions in increasingly complex situations.

UNDERSTANDING OUR ENVIRONMENT

GRADE 8	GRADE 9
INTERACTING WITH OUR ENVIRONMENT Recognizes that living things interact with other living and non-living parts of the environment. Identifies interactions that occur among living organisms in the local environment: • plant and plant • plant and animal • animal and animal. Describes the effect of non-living parts of the local environment on living organisms: • light • soil • water • temperature. Recognizes the sun as the original source of all energy in the environment. Describes the flow of energy in living things: • food chains • food webs. Recognizes the delicate balance that exists among living and non-living factors present in the environment. Recognizes the ways in which human practices have affected: • inhabitants of the local environment • balance among living and non-living factors in the environment. Recognizes that individuals and society have the ability to protect and improve balance among living and non-living factors in their environment.	**MONITORING THE LOCAL ENVIRONMENT** Identifies major forms of pollution in the local environment: • air pollution • water pollution • soil pollution • noise pollution. Describes local situations where human activity has altered living and non-living elements of the environment: • development of a local resource • disposal of solid wastes/sewage • land-use practices • use of biocides • population growth. Describes ways in which local use of natural resources has upset ecological balance and threatens environmental quality. Recognizes how the use of certain technologies has created/intensified local environmental problems. Recognizes the value of biodegradable materials in reducing the impact of the products we use on the environment. Recognizes that individuals and society have the ability to monitor and manage their use of resources and environment.

USING MATERIALS AND PRODUCTS

GRADE 8	GRADE 9
WORKING WITH SOLUTIONS Recognizes the properties of familiar household solutions and mixtures. Distinguishes between solutions and non-solutions. Gives familiar examples of solutions that are composed of: • solid and gas • gas and liquid • liquid and liquid • solid and solid • gas and gas. Demonstrates an understanding of techniques used to: • separate mixtures • recover solutes from a solution. Distinguishes between the properties/uses of household solutions that: • are water-based • contain solvents other than water. Identifies factors/conditions that affect the solubility of materials: • temperature • choice of solvent. Identifies factors/conditions that affect speed of dissolving: • temperature • particle size • mechanical movement. Distinguishes between diluted, concentrated and saturated solutions. Describes the effect of the strength of a solution on its freezing/boiling points. Demonstrates crystal formation through the use of super-saturated solutions.	**USING CHEMICAL PRODUCTS** Recognizes chemical and physical properties of familiar household substances. Identifies/distinguishes between chemical and physical change in household substances. Recognizes that chemical substances react according to predictable patterns. Demonstrates an understanding of acid and base substances used in the home: • natural properties of acids/bases • reactions of acids/bases with other household substances • their usefulness and potential dangers. Identifies factors that affect the reaction rates of chemical products used in the home: • temperature • concentration • surface area. Describes the nature of chemical changes that occur through oxidation: • burning • corrosion. Recognizes the usefulness, as well as the potential dangers, of chemical substances/reactions used in the home. Demonstrates an understanding of safe procedures for handling and storing potentially dangerous chemical products.

TECHNOLOGY AT WORK

GRADE 8	GRADE 9
USING ENERGY AND MACHINES Explains the relationship between force, motion, work and energy in real life situations. Recognizes how the forces of gravity and friction affect work that is accomplished. Demonstrates, through the use of simple labour saving devices, how simple machines help us to do work: • transfer of energy • increase/decrease in speed • change in direction of force • increase/decrease in force. Recognizes how combinations of simple machines are used in familiar mechanical systems and technologies to change direction/speed/magnitude of force. Identifies major sources/forms of energy used to power mechanical systems: • chemical • mechanical • heat • electrical. Recognizes that machines transfer energy from one form to another in doing work, and that useful energy is often lost in the form of heat. Describes energy: • flow/transformation/efficiency in familiar mechanical systems. Distinguishes between renewable and non-renewable sources of energy. Recognizes the rapid rate at which non-renewable sources of energy are being used by society, and the need to conserve these sources of energy.	**ELECTRICAL SYSTEMS IN THE HOME** Demonstrates an understanding of the basic principles of static electricity and magnetism. Describes the interrelationship between magnetism and an electric current. Gives examples of electrical circuits, identifying: • the source of electricity • the conducting path • energy users along the path. Recognizes methods of producing electrical energy for home consumption: • generators • chemical action. Describes basic principles of electrical resistance and applies this knowledge in: • selecting appropriate conductors • recognizing how electrical technologies produce light and heat. Demonstrates, through sketches/assembly/construction, an understanding of basic household circuitry: • series and parallel circuits • conductors and insulators • switches • short circuits • safety features. Relates principles of magnetism and electricity to the operation of familiar electrical technologies used in the home. Illustrates energy flow/transformation in familiar electrical technologies. Recognizes hazards inherent in the use of electricity: • identifies potentially dangerous situations • predicts possible consequences of unsafe habits/routines. Monitors personal consumption of electrical energy in the home, recognizing strategies that will ensure its efficient use.

LIFE FORMS AND CHANGES

GRADE 8	GRADE 9
GROWING PLANTS Recognizes the importance of plants as basic producers of food. Describes how energy for all living things is provided through the process of photosynthesis. Identifies general characteristics and specializations in the structure of vascular plants: • leaf • stem • root • flower. Recognizes that living plants function as the total of their structural systems and the life processes they perform. Demonstrates an understanding of the ways in which plants reproduce in natural and specialized environments: • propagation by vegetative reproduction • flowering and seeds. Describes how specialized varieties of plants are developed through programs of controlled breeding. Identifies essential natural requirements for germination and plant growth. Recognizes how technology may be used to maximize plant growth: • fertilization/growth supplements • aeration/liming • hydroponics • pesticides/herbicides. Identifies symptoms of plant stress that may be caused by an imbalance in essential growth requirements or by plant diseases and pests. Recognizes biological and chemical methods of controlling plant diseases and pests.	**DIVERSITY IN LIVING THINGS** Illustrates, through example, diversity in the size, shape and physical structure of living things present in the immediate environment. Identifies adaptive structures/behaviours of local organisms that enable them to survive in their environments. Recognizes that diversity in living things has been caused by the adaptive response of organisms to their environment. Recognizes that organisms may become extinct if there is lack of diversity/adaptation/specialization. Explains why features of particular species change over generations through the process of natural selection. Affirms the need to organize living things by classifying them into groups and sub-groups according to structural characteristics. Displays an understanding of systems used to classify living organisms: • Linnaean system of classification • recent developments in classification. Describes the diverse stages/forms of life in the life cycles of organisms common to the local environment: • complete metamorphosis • incomplete metamorphosis. Recognizes how certain species perform diverse functions through the use of specialized structures and appendages: • social insects • human body.

FACILITIES AND EQUIPMENT

FACILITIES

While it is desirable to conduct science instruction in a laboratory setting of some type, a conventional science laboratory is not essential. The science program can be delivered in a regular classroom or other multi-purpose room available within the school. Existing space and resource can be adapted in a number of ways to provide a practical area for group instruction and individual study in science.

The suggestions that follow may be useful in providing appropriate work space and facilities for an activity-oriented science program in situations where a conventional laboratory is not available.

- Provide appropriate space for students to work individually or in small groups by moving desks apart or together. Desks can be moved together to form larger surfaces on which to work if tables are not available.
- Obtain shelves/cupboards for the storage of science materials. It may be possible to loan suitable storage facilities from another area of the school or have these facilities built locally.
- Improvise/obtain a portable laboratory demonstration table. Ideally, the demonstration table should provide a work surface, and contain a sink, source of water and some storage space. A demonstration table of this nature might be constructed within the school or community.
- Provide students with alternative environments within the community for studying science. "Out-of-school" environments are valuable in illustrating the application of concepts/skills in the real world.

EQUIPMENT

Although some equipment may have to be purchased, many pieces of basic laboratory equipment can be collected from home or made locally. Items collected from home (e.g., jars of assorted size, plastic bottles, tin cans, egg cartons, copper wire, metal screens) may be used "as is" or reconstructed as substitutes for more expensive laboratory equipment. The processes of improvision and construction can provide valuable learning experiences for students as they practise basic skills and techniques, and see the results of their endeavours in the equipment they use. When obtaining materials, ensure that quantities are sufficient for small group work, thus facilitating maximum student participation.

Lists of suggested apparatus and supplies are provided on the pages that follow. These lists provide guidelines for furnishing the science room with materials that support the instructional activities described in this manual. Teachers should recognize that they may not require every item that is listed, and that equipment needs will be determined by the activities they select throughout the program. In most instances, a "scrounging list" taken home by students will produce much of the needed equipment. If purchasing equipment, it would be wise to consult local wholesalers and distributors for better buys than may be available through scientific supply houses.

SUGGESTED APPARATUS

aquarium tank (with air pump, filter, gravel and optional heater)
ammeter
asbestos apron
asbestos gloves/mittens
ball (e.g., tennis)
battery (car)
beaker (25 mL, 100 mL, 250 mL, 500 mL)
bicycle (for disassembly)
bucket
buzzers (assorted)
camera (optional)
can opener (handheld/cutting wheel)
chemical scoop
clamp
clock (old/collection)
clothes pin
collection of jars
cooler (or access to refrigerator/freezer)
dissecting scope
distillation flask
dishpan or pneumatic trough
doorbell (assorted)
dry cell (6 volt)
electric motor (for disassembly)
eye dropper
eyewash bottle
filmstrip projector
fire blanket
fire extinguisher
first aid kit
fishing rod and reel (for disassembly)
flashlight cell (size D)
flint lighter
funnel (e.g., 65 mm x 11 mm)
gardening flat and cover
glass plate (approximately 20 cm x 20 cm)
glass tubing (8 x 1.10 mm)
goggles
graduated cylinder
grow lamp (optional)
hand shovel
hot plate
insects (preserved)
light bulb (6 volt)
magnets (assorted)
magnifying glass
metre stick
microscope
microscope cover slips
microscope slides
nails
overhead projector
paintbrush (small/fine)
pencil sharpener (wall mount)
pulleys (assorted)
radiometer
refrigerator (access)
retort stand
ring clamp
rubber stopper
rubber stopper (1-hole, 2-hole)
rubber tubing (1/4 x 1/16)
ruler
screwdriver and screw
starter pots (e.g., 5 cm x 5 cm)
stirring rod
electrical switches (assorted)
tape recorder (optional)
teaspoon
terrarium (covered)
test tubes (15 mm x 125 mm; 20 mm x 150 mm)
test tube holder
test tube rack
thermometer
triple beam balance
voltmeter
watch glass
watering can
wire gauze pad
wire (insulated copper)

SUGGESTED SUPPLIES

alcohol (methyl)
aluminum foil
ammonia
antacid tablet
baking soda
bird nest (deserted)
black paper (20 cm x 20 cm)
cabbage leaves
calcium acetate
carbonated (bottled) pop
carrot top
celery stick
citrus/fruit juice
cloth (10 cm x 10 cm)
clothespin
coat hanger
construction paper (poster size)
cooking oil
cream of tartar
cup (opaque or styrofoam)
distilled water
drinking straws
filter paper
film (optional)
flowers (florist discards, potted, garden)
fuse (assorted)
garden/potting soil
grape juice (unsweetened)
grease pencil
hydrochloric acid (dilute)
hydroponic chemicals
iodine
iron filings
labels (self-sticking)
lemon juice
lime
litmus paper (red and blue)
magazine collection
markers (large, assorted colours)
markers (waterproof, assorted colours)
masking tape
matches (wooden)
orange
paper clips
paper (pH)
paper towel
pebbles/gravel
pencil crayons
petroleum jelly (small tube)
phenolphthalein indicator
pineapple top
plant pots (assorted)
plants (potted tulips, wood sorrel, prayer plant)
plaster of Paris
plastic baggies (sandwich)
popsicle sticks
potassium chloride
potassium chromate
potassium nitrate
potato
powdered milk
propane/natural gas
recording tape/cassette (optional)
rubber band
salt
sand
saw dust
seed catalogues
seeds (bean, radish, dwarf tomato)
sodium hydroxide solution (dilute)
sodium nitrate
sodium thiosulphite ("hypo") crystal
sour milk
staples
starch
steel wool
sugar (brown)
sugar (cube, granular)
sulfuric acid (dilute)
sweet potato
tacks
tape (masking)
tape (transparent)
tea (bag)
tea (iced crystals)
toothpicks
tweezers
twine
vanilla extract
vinegar
wooden splints
writing paper and envelopes

SAFETY IN THE SCIENCE CLASSROOM

The development of positive student attitudes toward safety is critical in the science program. An awareness of safety should be developed through a commonsense approach. Students should recognize that accidents can be avoided through advance planning and an awareness of hazardous situations.

When conducting experiments and investigations, students should be expected to:

- follow directions exactly as given
- understand the import of what they are doing
- maintain order and neatness in arranging equipment
- use prior knowledge in making judgments
- ask for advice when in doubt.

No laboratory work should be expected of students if they are not fully aware of possible hazards and preventative measures.

Students should also be encouraged to transfer the safety knowledge and attitudes developed in school to potentially dangerous situations they may encounter at home, at work and in the community.

RESPONSIBILITIES OF THE TEACHER

The most effective method of teaching safety is by example. The procedures and attitudes consistently displayed by the teacher influence students more than actually teaching a unit on safety. The teacher should be conscious of the example being set, and encourage development of the following habits and attitudes:

- careful observation and alertness at all times
- constant application of safety techniques
- constructive criticism of experimental procedures
- planning of procedures and advance identification of the safety responsibilities associated with these procedures.

Teachers must provide adequate supervision of students at all times, and emphasize accident prevention. Students must be alerted to situations that are unsafe or hazardous.

RESPONSIBILITIES OF THE STUDENT

At the beginning of the course, students should be alerted to general safety precautions and safety procedures. Specific hazards and precautions related to the use of equipment and chemicals should be discussed as the materials are used. Students must plan their laboratory investigations and procedures in ways that will minimize the possibility of accidents. All accidents and unexpected events that occur should be reported and discussed with the teacher.

It is advised that a **Student Safety Contract** be issued early in the school year, after students have been alerted to general safety precautions and procedures. Use of a safety contract will increase the students' awareness of personal responsibilities in the safety of self and others. A sample student safety contract is provided on the following page.

STUDENT SAFETY CONTRACT

I will:

- Follow all safety instructions given by the teacher.
- Protect eyes, face, hands, and body while conducting class activities.
- Carry out good housekeeping practices
- Be able to locate first-aid and fire fighting equipment
- Conduct myself in a responsible manner at all times in a laboratory situation.

I, _____, have read and agree to abide by the safety regulations as set forth above and any additional printed instructions provided by the teacher and/or school. I further agree to follow all other verbal and written instructions given in class.

Date _____

_____
Signature

SAFETY GUIDELINES

Teachers must be familiar with safety policies and statements adopted by their employing board. In the absence of such statements, teachers should be aware of specific hazards that students face in the science program and take suitable precautions to avoid such hazards. Teachers must also be familiar with policy and information provided in Alberta Education's monograph *Clarification of Statements Prohibiting the Use of Human Body Substances in the Alberta Science Curriculum*, 1988. (Due to the potential risk of infection from hepatitis and AIDS, all activities involving the extraction and analysis of samples of human fluid or tissue are prohibited in Alberta schools.) Additional safety information is provided in *Safety and Organization in School Science Facilities*, a resource book for elementary and secondary schools by Science Education Consultants, Alberta Education, 1986.

While no set of safety rules can be complete, the statements that follow will give direction in establishing a set of appropriate safety procedures for the science program.

- Never leave students unsupervised.
- Insist upon the use of correct laboratory techniques.
- Strictly enforce rules with regard to behaviour.
- Avoid any laboratory procedure if there is any doubt as to its safety.
- Locate and teach the use of appropriate safety equipment (e.g., eyewash, first aid kit, fire blanket, fire extinguisher).

- Provide medical attention immediately if there is any question as to its need.
- Insist that students carry out a procedure only after they understand how it is to be done.
- Ensure that students are properly dressed (e.g., wearing protective glasses or aprons if required; no loose clothing or hair that will interfere with equipment and materials).
- Provide instruction in appropriate procedures for using possibly hazardous equipment and supplies such as bunsen burners, alcohol lamps, candles, acids/bases or solvents.
- Provide adequate ventilation, working space and suitable equipment for each investigation.
- Label all chemicals clearly.
- Store potentially dangerous chemicals and apparatus in a locked and well-organized storeroom.
- Insist on well-planned and organized procedures, and on cleanliness of hands, benches, tables and equipment.
- Do not allow students to use concentrated acids or bases, volatile solvents, sodium, potassium, phosphorus or hydrogen.
- Do not heat anything in glass other than pyrex.
- Do not heat test tubes over an open flame.
- Use 110 volt electricity only in CSA approved apparatus.
- Do not force glass tubing through rubber stoppers.
- Do not allow activities that involve the extraction or analysis of human tissue or fluid (e.g., cell scrapings, blood samples).

WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM

The Workplace Hazardous Materials Information System (WHMIS) is a hazard communications program designed to protect workers across Canada from injuries and illnesses caused by exposure to chemicals. The program uses federal and provincial legislation to ensure:

- the labelling of hazardous materials
- the provision of material safety data sheets (MSD's) by suppliers of hazardous materials
- worker education/instruction programs.

WHMIS provides a way for teachers to obtain information about hazardous materials that may be used in the science program. Science teachers should consult WHMIS in order to identify the hazards of various materials and the precautions to take when using these materials.

Posters, booklets and pamphlets that describe features of WHMIS are available at no cost from the nearest Regional Office of Alberta Occupational Health and Safety.

Other resource materials on WHMIS include a videotape *WHMIS: Working for You* and a reference manual *WHMIS Core Material: A Resource Manual for the Application and Implementation of WHMIS (1989 Revised Edition)*. These materials can be ordered through the Alberta Association of Safety Personnel/Canadian Society of Safety Engineers Provincial Body at the address provided below.

AASP/CSSE Provincial Body
P.O. Box 262, Main Post Office
Edmonton, Alberta
T5J 2J1

INTERPERSONAL SKILLS AND COOPERATIVE LEARNING

Many science activities provide opportunity for students to develop skills by working in cooperative learning situations. Group work often provides students with a less threatening environment, where they may be more willing to take the risks associated with inquiry, problem solving and decision making. Students participating in group activities can learn new strategies from others, and refine their own processing skills.

Skills best learned in group settings may include the ability to:

- clarify one's own ideas
- evaluate the ideas of others
- compare alternatives.

CLARIFICATION/EXAMPLE

A Paired Problem-Solving Strategy[1]

Students are divided into pairs (problem solver, recorder) in order to work together in solving a problem. The use of a "thinking-aloud" procedure allows the student to see how their partner thinks and solves problems. Thinking steps are thus open to view and can be observed and communicated. The procedure used is:

1. One member (the problem solver) "thinks aloud" while solving a given problem.
2. The other member (the recorder) listens carefully, noting the steps taken in the solving of the problem. At the end of this "think aloud" procedure, the recorder may ask clarification questions of the problem solver and/or may point out errors made in the problem-solving process.
3. Roles are reversed, repeating the same problem.
4. The modification/extension of both strategies are discussed with each person (or both if agreement is reached) documenting the best "modified" strategy.

This strategy could be expanded to include three people by subdividing the recorder's role into recorder and questioner. The three roles would rotate.

Cooperative learning also offers opportunities for enhancing interpersonal skills among students. As students work in group settings, problems in social interaction may arise. A strategy for systematically analyzing a social problem is provided on the next page. This strategy helps students to identify:

- reasons for the difficulty/conflict
- strategies that may avoid the difficulty/conflict another time.

Teacher modelling and student use of this strategy may improve classroom climate, and enable students to gain confidence in their ability to interact and communicate effectively with one another.

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1. Adapted from *SPELT: A Strategies Programme for Effective Learning and Thinking Inservice Edition*, SPELT International Ltd., p. 197. Copyright 1987 by R. Mulcahy, K. Marfo, D. Peat and J. Andrews. Reprinted by permission.

SPOT (SOCIAL PROBLEM-SOLVING STRATEGY)

Description of Strategy

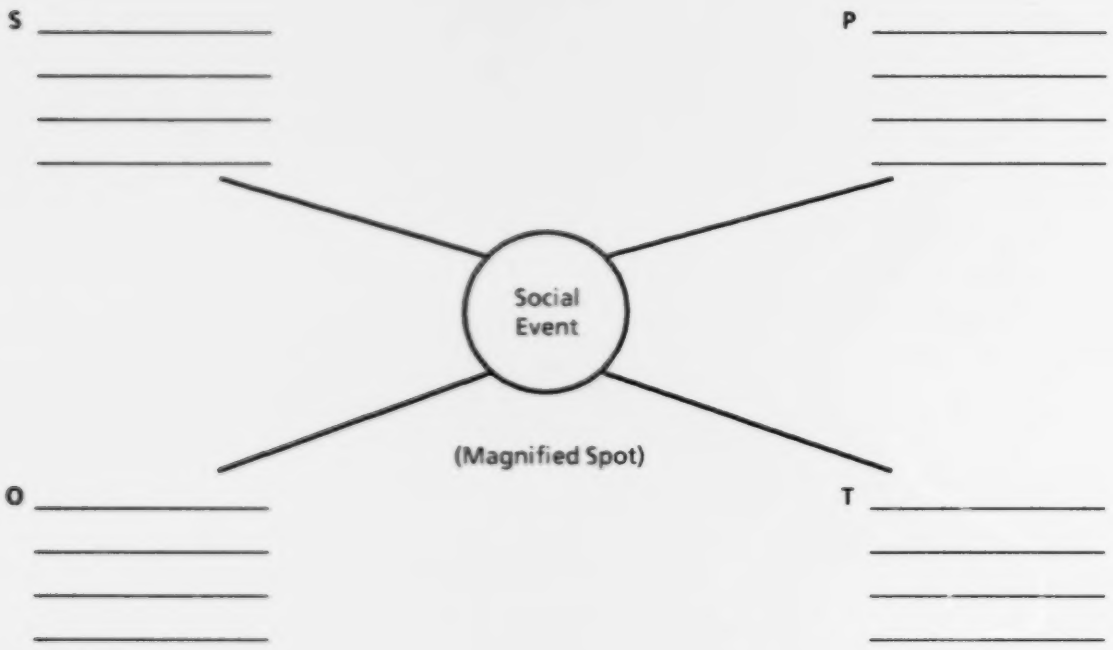
S: Setting: Who? What? Where? When?

P: Problem: What's the situation to be solved?

O: Order of action: What happened?

T: Tail End: What can be done next time?

Problem-Solving Chart:



From *Strategies for Teaching Students with Learning and Behaviour Problems* by Dr. C. Bos, and S. Baughn. Copyright 1988 by Boston, Allyn and Bacon. Reprinted by permission.

THEME A

INTERACTING WITH OUR ENVIRONMENT

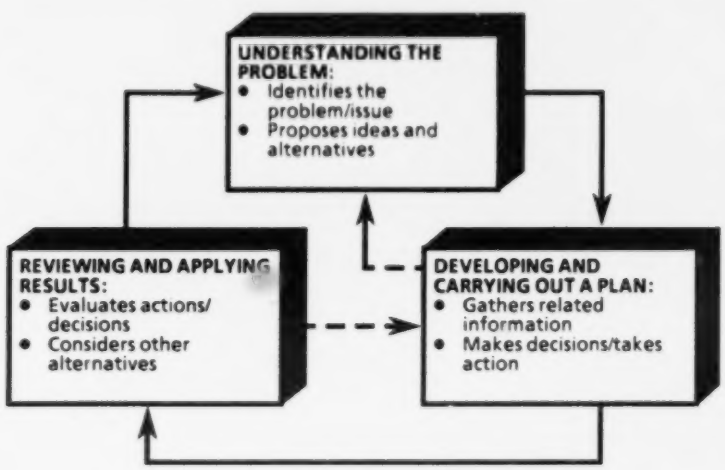
Students will investigate the interactions that occur among living and non-living parts of their environment. Activities will include first-hand observation of living things in the immediate environment, and should emphasize those relationships and interactions having the greatest impact on life in the local community. Investigations will enable students to recognize:

- the ways in which people affect the environment
- the ways in which the environment affects our lives
- the need to monitor and manage the local environment.

Teachers are encouraged to reference the "Generic Strategies" provided in this manual when planning for instruction. Strategies particularly relevant to the learning objectives and activities outlined in this theme can be found in:

- The Nature of Science
- The Role of Science and Technology in Society
- Communication Skills
- Evaluation.

A MODEL FOR MAKING DECISIONS ON ENVIRONMENTAL ISSUES


UNDERSTANDING THE PROBLEM:
• Identifies the problem/issue
• Proposes ideas and alternatives
DEVELOPING AND CARRYING OUT A PLAN:
• Gathers related information
• Makes decisions/takes action
REVIEWING AND APPLYING RESULTS:
• Evaluates actions/ decisions
• Considers other alternatives

CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

- Recognizes that living things interact with other living and non-living parts of the environment.
- Identifies interactions that occur among living organisms in the local environment:
  - plant and plant
  - plant and animal
  - animal and animal.
- Describes the effect of non-living parts of the local environment on living organisms:
  - light
  - soil
  - water
  - temperature.
- Recognizes the sun as the original source of all energy in the environment.
- Describes the flow of energy in living things:
  - food chains
  - food webs.
- Recognizes the delicate balance that exists among living and non-living elements present in the environment.
- Recognizes the ways in which human practices have affected:
  - inhabitants of the local environment
  - balance among living and non-living elements in the environment.
- Recognizes that individuals and society have the ability to protect and improve balance among living and non-living elements in their environment.

SKILLS

- Identifies common plants and animals found in the local environment.
- Uses appropriate inquiry skills in monitoring the effect of abiotic (non-living) factors on local plants/animals (e.g., light, soil, water, temperature):
  - designs experiments
  - gathers and processes data
  - interprets data
  - applies findings to local situation.
- Gathers, processes and interprets information related to the interdependence and relatedness of living organisms in the local environment:
  - observes the distribution patterns of plants and animals
  - observes and infers animal activities that indicate dependencies for food or protection
  - observes and infers examples of commensalism/mutualism/parasitism.
- Gathers, processes and interprets information related to energy flow in the local environment:
  - observes and infers food chain relationships
  - classifies familiar animals as producers/consumers/decomposers
  - constructs diagrams/models of food chains/food webs.

SKILLS (continued)

- Performs a plant and animal census within a given plot in the local community, observing and inferring:
  - distribution of plants/animals in relation to abiotic factors
  - interrelationships that exist among plant and animal inhabitants.
- Uses decision-making skills in analyzing a local environmental issue:
  - identifies a problem/issue related to use of the environment
  - gathers information related to the issue through observation/interview/research
  - evaluates information gathered (i.e., identifies cause and effect, predicts the effects of alternative responses to the issue)
  - chooses actions/makes decisions that minimize environmental impact
  - anticipates long-term consequences of actions taken.

ATTITUDES

- Displays a positive attitude toward self and the study of science:
  - assumes responsibility for personal conduct
  - performs investigations and completes assignments independently and in cooperation with others
  - practises strategies for resolving interpersonal conflict
  - shows interest and curiosity through willingness to ask questions/share observations and ideas/seek answers.
- Appreciates the extent to which people are dependent upon and influenced by their environment.
- Shows concern for changes made to the natural environment by technology and society.
- Demonstrates commitment, through discussion and personal action, to protecting and improving the environment.
- Accepts responsibility for the care of living organisms in both natural and artificial environments.
- Values the use of scientific knowledge in making decisions that affect the health of our environment.

INTEGRATION ACTIVITIES

LANGUAGE ARTS

Students will use a variety of communication skills throughout activities in this theme. Activities will require students to use:

- "comprehension skills" when gathering and interpreting data about the environment
- "inquiry skills" when monitoring the effects of human practices on the environment
- "reporting skills" when presenting data.

Teachers are encouraged to identify appropriate strategies for developing these skills through conferencing with the language arts teacher. Learning activities that develop an awareness of the role of science and technology in society may involve research and writing activities that can be integrated with the language arts program.

MATHEMATICS

Students will use a variety of mathematical skills in gathering and interpreting data. These skills may include:

- classifying data
- reading and interpreting tables/charts/graphs
- constructing tables/charts.

Cooperative planning will provide opportunities for students to apply mathematical skills in a scientific context. Data obtained in science class can be organized and analyzed in mathematics class.

SOCIAL STUDIES

Teachers may wish to integrate the investigation of a local environmental issue with social studies classes. Through activities in current affairs, social studies students might:

- identify an environmental issue of local concern
- gather information about the issue
- identify government agencies involved in the issue.

Science class could then be used to:

- gather information through observation/interview
- evaluate the information gathered
- identify/choose possible courses of action
- consider the short/long-term effects of actions taken.

PRACTICAL ARTS

Students will reinforce thematic concepts/skills in their practical arts programs by:

- recognizing the harmful effects of improper waste disposal
- relating sanitation/disposal procedures used within the school and community to global environmental concerns
- examining alternative methods of waste disposal.

COMMUNITY PARTNERSHIP OPPORTUNITIES

- Interview a long-time resident of the community who can describe ways in which the local environment has changed during the last 20-50 years.
- Invite a wildlife officer, agriculturalist or forestry official to speak to students about cyclic phenomena in wildlife, the effects of a forest fire, or some similar topic.
- Visit a local greenhouse/nursery. Ask the horticulturalist to describe ways in which seasonal changes affect plant growth.
- Interview local officials responsible for waste disposal. Evaluate local methods of waste disposal in terms of their effects on the environment. Identify alternatives that may reduce the environmental impact of methods currently used.
- Investigate the use of recycling programs in the local area. Identify materials that are currently recycled (e.g., bottles, paper, scrap metal), and other materials that should be recycled.
- Visit local facilities used for water chlorination/sewage treatment/waste disposal. Evaluate these facilities in terms of their effect on the local environment.
- Ask a meteorologist to explain causes of the greenhouse effect. Discuss the impacts of this phenomenon on the local environment.
- Interview a wildlife officer and discuss the need for hunting and fishing regulations. Ask the officer to explain why local wildlife populations may fluctuate.
- Visit a local supermarket. Identify a variety of different food products and describe the food chain/food web associated with each.
- Visit a remote region in the local area that is not inhabited by humans. Perform a plant and animal census within this region. Compare the census to one taken within a region inhabited by humans.
- Invite local aldermen, councillors or MLA's to discuss current policy and debate relating to pollution and environmental quality.
- Observe land erosion by taking a field trip to an eroded area or an erosion prevention project.

BASIC RESOURCE CORRELATION

Science Plus Technology and Society 8
- Unit: Interactions

SUGGESTED ACTIVITIES

Science Plus Technology and Society 8 and its corresponding *Teacher Resource Book* provide a variety of activity-based investigations that support the learning objectives identified in this theme. The activities that follow may be used to supplement those provided in the basic learning resource. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

Recognizes that living things interact with other living and non-living parts of the environment.

1. Visit a local field, park, pond or the school yard. Identify and record the living (biotic) and non-living (abiotic) parts of this environment. Display results on poster paper. Discuss the interactions that are possible among the biotic and abiotic parts of this environment.

2. Choose an organism from the local environment (e.g., rabbit). Identify all the biotic and abiotic factors that are part of this organism's environment (e.g., grass, trees, water, foxes). Classify each factor as biotic or abiotic.

   Strategies that may assist students to develop classification skills are provided in The Nature of Science, "Processing Data".

3. Observe an established aquarium or terrarium. Identify biotic and abiotic factors in this environment, and the interactions that occur between these factors. Relate observations to interactions in the local community.

   Attribute guides provide an effective means of structuring student observations. A sample attribute guide has been provided in The Nature of Science, "Gathering Data".

4. Collect nature/wildlife pictures found in magazines. Identify living and non-living elements depicted in these pictures and possible interactions that may occur.

LEARNING OBJECTIVE

Identifies interactions that occur among living organisms in the local environment:
- **plant and plant**
- **plant and animal**
- **animal and animal.**

1. Observe an established aquarium or terrarium. Classify the interactions that occur within this environment as plant/plant, plant/animal, and animal/animal.

2. Visit a local field or forested area. Identify and record the names of plants and animals found in this area. Design a poster that illustrates interactions that occur between these plants and animals.

3. Investigate the interactions that occur between living and non-living organisms in a farm environment. Discuss these interactions with a farmer. Prepare a report that synthesizes the information gathered, using strategies provided in Communication Skills, "Making Summaries".

4. Collect pictures and photographs of various natural environments. Study each picture/photograph and identify plant/plant, plant/animal and animal/animal interactions that may possibly occur.

5. Find a deserted bird nest. Carefully take the nest apart. Sort the materials according to type (e.g., living, non-living). Make charts that illustrate:

   - different kinds of materials used to build the nest
   - the living things that produced these materials
   - the interdependence of birds with other living organisms.

6. Conduct a debate: "Grass Depends on People" versus "People Depend on Grass". Structure the debate using suggestions provided in Communication Skills, "Strategies for Discussing and Debating".

LEARNING OBJECTIVE

Describes the effect of non-living parts of the local environment on living organisms:
- **light**
- **soil**
- **water**
- **temperature.**

1. Imagine that one or more of the non-living (abiotic) parts of the local environment have been contaminated. Predict the effects of this contamination upon populations of living things and other non-living resources. Suggest strategies that may be used to resolve the problem. Devise methods of preventing similar tragedies in the future.

   Assist students to generate ideas about possible relationships and to make predictions using questioning techniques similar to those described in The Nature of Science, "Proposing Ideas".

2. Ask students (individually or in groups) to locate an area close to the school where a variety of living organisms can be found.
   e.g.,
   - a square metre of lawn
   - the earth under a log
   - a weed patch in a nearby field
   - the edge of a stream
   - a densely wooded area.

   Mark the area off and observe all life forms and interactions present. Record the following data with respect to observations that are made.

   - date and time of observation
   - location
   - size of area
   - principal growth
   - plant and animal census
   - temperature
   - sunlight
   - soil conditions.

Draw a map that shows the location of all living organisms included in the census. Identify non-living elements that have influenced the distribution of plants and animals within this area.

3. Visit a pond and mark a path from the pond through a field into a wooded area. At two foot intervals, randomly toss a hoop and take a sample of plant life. Label each sample with its distance from the pond. Continue taking samples up to twenty feet into the wooded area. Mount the samples on poster paper to illustrate the direction of the path. Observe a plant from each sample and note differences among the plants along the path. Identify abiotic factors along the path that may have affected plant growth. Hypothesize the effects of these abiotic factors on biotic organisms in the area.

LEARNING OBJECTIVE

Recognizes the sun as the original source of all energy in the environment.

1. Encourage students to predict what might happen if:

   - the sun were suddenly "shut off"
   - the sun began to give off more/less energy
   - the earth began to move closer to/further away from the sun.

   Strategies provided in The Nature of Science, "Strategies for Developing the Inquiry Skills" will assist students to develop skills of predicting and hypothesizing.

2. Investigate the conversion of light energy to food through the process of photosynthesis. Discuss the following statement:

   "Plants store the sun's energy."

3. About one-half of the sun's energy that strikes the top of the atmosphere reaches the surface of the earth. Investigate what happens to the solar energy that reaches the surface of the earth.

4. Write a science fiction composition entitled "The Sun Stopped Shining". Use the pre-writing strategies provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

5. Design a personal project that illustrates how humans use the sun as a source of energy.

LEARNING OBJECTIVE

Describes the flow of energy in living things:
- **food chains**
- **food webs.**

1. Investigate local food chains. Illustrate how a number of food chains can intermesh to form a food web. Draw diagrams or make posters to depict the interrelationships discovered.

   Ask questions that will encourage students to apply their knowledge of plant/animal interactions in determining cause and effect relationships and in making predictions.

   e.g.,
   - What happens to a food chain/web when one member becomes over-abundant or scarce?
   - How do chemical and physical factors affect food chains?
   - What factors may affect the size of a given population?
   - What is the basic source of energy for all members of a food chain/web?

Describe a simple 3-step or 4-step food pyramid. Determine where the energy originates, and what happens to the energy at each level in the pyramid. Draw and label a diagram of the energy cycle.

2. Draw and label a food chain for several different carnivores and herbivores living in your area. Identify producers, primary consumers and secondary consumers within each chain. Draw a food web that includes these food chains.

3. Draw a three level food pyramid. Discuss what might happen to the food pyramid if fire destroys the bottom portion. Draw a new pyramid to illustrate the outcome.

4. Discuss the following terms as they relate to plants, animals and interactions that are investigated:

   - adaptation
   - competition
   - predation
   - producer
   - consumer
   - decomposer.

   Vocabulary development strategies are provided in Communication Skills, "Developing Technical Vocabulary".

5. Collect wildlife pictures from magazines. Identify the organisms illustrated in these pictures as producers, primary consumers/secondary consumers, parasites, scavengers and/or decomposers.

6. Describe three stages of succession that might occur in the local environment over the next ten years. Predict changes that may occur in local vegetation and the effects these changes would have on the biotic and abiotic community.

LEARNING OBJECTIVE

Recognizes the delicate balance that exists among living and non-living factors present in the environment.

1. Identify ways in which man's activities have altered and changed the natural environment in your area. Infer the effects of these changes on local plants and animals.

   Interview a long-time resident who can describe ways in which the local environment has changed over the last 20-50 years. Collect pictures and newspaper reports that might illustrate some of these changes.

2. Imagine that a lake has become poisoned through the disposal of untreated wastes. Discuss ways in which the balance between living and non-living elements in this environment might be affected.

3. Research the effects of the spruce budworm upon the spruce tree population. Infer how changes in the spruce tree population may affect other biotic and abiotic factors present in the environment.

LEARNING OBJECTIVE

Recognizes the ways in which human practices have affected:
- **inhabitants of the local environment**
- **balance among living and non-living elements in the environment.**

1. Identify a variety of biocides that are used locally. Evaluate the use of these biocides by considering their advantages/disadvantages and effects on the local environment. Discuss alternatives to the use of biocides in controlling pests. Appropriate strategies for evaluating the use of biocides are provided in Communication Skills, "Using Critical Thinking Skills".

   Collect media reports of environmental/health problems associated with the use of biocides in the local community. Provide opportunity for students to conduct debates on the local use of insecticides/herbicides.

2. Invite a wildlife officer or biologist to discuss:

   - cyclic phenomena in wildlife
   - the effects of environmental changes on wildlife
   - endangered species
   - wildlife conservation.

3. Identify various sources of pollution. Classify pollutants according to their effect on the environment.

   e.g.,

Air Pollution	Water Pollution
smoking	acid rain
biocides	industrial run-off
nuclear testing	chemical disposal
automobile exhaust	sewage

Soil Pollution	Noise Pollution
acid rain	industrial machines
garbage/litter	stereos
biocides	aircraft
industrial refuse	boats/motor cycles

4. Invite a representative from local government to provide information about actual or potential pollution problems in your area (e.g., acid rain, sulphur dioxide, radio-active wastes).

5. Research the development of a resource within the local community (e.g., hydro-electric plant, coal mine, petroleum recovery project). Incorporate the use of several strategies in obtaining and interpreting information about the project.

   - interviews/guest speakers
   - field trips
   - surveys
   - semantic webs/flow charts.

   Evaluate the development of this resource by considering effects of the project on:

   - the physical environment
   - local plant and animal populations
   - human populations.

LEARNING OBJECTIVE

Recognizes that individuals and society have the ability to protect and improve balance among living and non-living factors in their environment.

1. Investigate alternative methods of disposing of solid waste.
   e.g., • open dumping
   • incineration
   • sanitary landfill
   • salvage
   • pulverization/compaction.

   Evaluate local methods used to dispose of solid wastes. Consider alternatives that might reduce environmental pollution.

2. Distinguish between "biodegradable" and "non-biodegradable" pollutants. Identify local pollutants of each type, and appropriate strategies for disposing of each kind of waste material.

   Investigate the disposal of toxic waste materials. Collect and discuss media reports on problems associated with the disposal of toxic wastes. Does your community have a system for disposing of toxic wastes?

3. Identify conservation programs/practices that exist within the local community.
   e.g., • recycling centres
   • use of biodegradable products
   • soil conservation practices
   • stocking/restocking lakes with fish
   • hunting/fishing regulations.

   Evaluate the effectiveness of these programs in maintaining a quality environment. Consider other practices that might reduce the detrimental effects of human activities on the environment.

4. Identify local issues related to pollution of the atmosphere/soil/water (e.g., industrial emissions, sewage treatment, use of biocides/chemical fertilizers). Gather information on these issues by taking field trips and conducting surveys/interviews.

   Investigate government pollution guidelines/policies with respect to the issues identified. What measures have been taken to meet these guidelines? Are current guidelines effective in controlling the problem? If not, what personal/community actions should be taken?

5. Students should recognize that although many of today's environmental problems have been caused by developments in science and technology, solutions to these problems are also often provided through scientific research and technological development.
   e.g., • disposal of radioactive wastes
   • emission control systems for automobiles and industry
   • scientific management of wildlife
   • development of alternative sources of energy

   Encourage students to consider the relationship between science/technology and environmental quality by using ideas provided in The Role of Science and Technology in Society, "Interactions Among Science, Technology and Society".

6. Conduct a classroom debate: "To recycle or not to recycle". Structure the debate using strategies provided in Communication Skills, "Strategies for Discussing and Debating".

THEME B

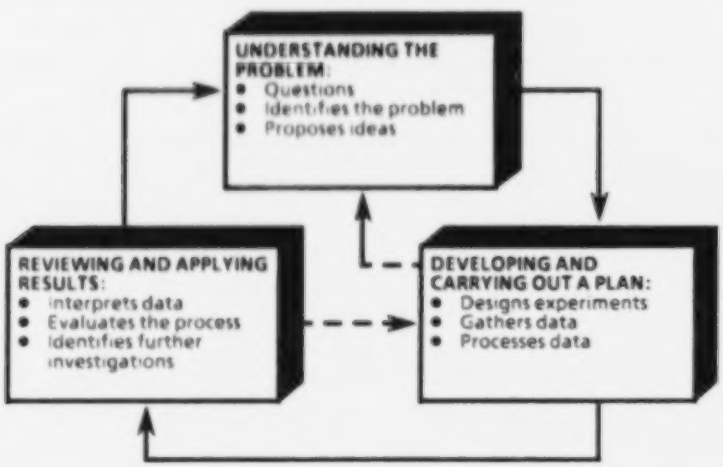
WORKING WITH SOLUTIONS

By carrying out a series of controlled experiments, students will investigate the properties and uses of solutions and substances found in their homes. Activities must emphasize the study of those household and personal care substances already familiar to students through frequent use in real life situations. Students will develop a strategy and respect for the safe handling of laboratory equipment and supplies, and should become aware of appropriate procedures for handling potentially dangerous materials that they may encounter in real life situations.

Teachers are encouraged to reference the "Generic Strategies" provided in this manual when planning for instruction. Strategies particularly relevant to the learning objectives and activities outlined in this theme can be found in:

- The Nature of Science
- Communication Skills
- Evaluation.

A MODEL FOR CONDUCTING SCIENTIFIC INQUIRY



CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

- Recognizes the properties of familiar household solutions and mixtures.
- Distinguishes between solutions and non-solutions.
- Gives familiar examples of solutions that are composed of:
  - solid and gas
  - gas and liquid
  - liquid and liquid
  - solid and solid
  - gas and gas.
- Demonstrates an understanding of techniques used to:
  - separate mixtures
  - recover solutes from a solution.
- Distinguishes between the properties/uses of household solutions that:
  - are water-based
  - contain solvents other than water.
- Identifies factors/conditions that affect the solubility of materials:
  - temperature
  - choice of solvent.
- Identifies factors/conditions that affect speed of dissolving:
  - temperature
  - particle size
  - mechanical movement.
- Distinguishes between dilute, concentrated and saturated solutions.
- Describes the effect of the strength of a solution on its freezing/boiling point.
- Demonstrates crystal formation through the use of super-saturated solutions.

SKILLS

- Measures mass/capacity/temperature/time, using units, tools and procedures that are appropriate to the task being performed.
- Practises safe procedures for handling and storing laboratory/household materials that are potentially dangerous.
- Uses inquiry skills to investigate familiar household solutions, demonstrating ability to:
  - manipulate materials
  - accurately observe/measure
  - identify and control variables
  - hypothesize and infer relationships between variables
  - interpret graphs
  - make predictions.
- Classifies familiar mixtures as solutions or non-solutions.
- Performs experiments in order to determine:
  - factors affecting solubility
  - factors affecting speed of dissolution
  - effect of solution strength on freezing/boiling point.

SKILLS (continued)

- Prepares solutions in a manner that demonstrates an understanding of:
  - laboratory procedure
  - solubility concepts.
- Identifies appropriate methods of separating partners of a solution.
- Demonstrates manipulative skill and an understanding of laboratory procedure in:
  - using filter paper
  - recovering a solute by evaporation
  - using the distillation process
  - growing crystals
- Uses problem-solving skills in determining effective techniques for removing undissolved material/impurities from solutions in practical situations:
  - gathers information/proposes alternatives
  - selects an alternative/builds a design
  - tests/evaluates/applies the design.

ATTITUDES

- Displays a positive attitude toward self and the study of science:
  - assumes responsibility for personal conduct
  - performs investigations and completes assignments independently and in cooperation with others
  - practises strategies for resolving interpersonal conflict
  - shows interest and curiosity through willingness to ask questions/share observations and ideas/seek answers.
- Appreciates the extent to which solutions are a part of both natural and manufactured products, and how science and technology have contributed to the development of a variety of household products that we use each day.
- Realizes the usefulness of scientific inquiry skills in gathering information and explaining natural phenomena.
- Displays an attitude of personal safety, and concern for the safety of fellow students when handling hazardous equipment and supplies in the laboratory.
- Appreciates the potential dangers of hazardous chemical substances found at home and elsewhere in the community.

INTEGRATION ACTIVITIES

LANGUAGE ARTS

Skills of "listening", "discussing", "reading" and "viewing" are an integral part of gathering data and conducting investigations. Students will use skills of "giving and following directions" when preparing solutions and mixtures. Teachers are encouraged to discuss effective strategies for developing these skills with the language arts teacher.

MATHEMATICS

Students will be using skills developed in mathematics class when they:

- measure mass/capacity/temperature/time
- classify and display data in table/chart form
- interpret graphs
- interpret ratios that describe the concentration of solutions.

Science teachers are encouraged to conference with the mathematics teacher in establishing appropriate strategies for reinforcing mathematical concepts/skills. Plan activities that will enable students to:

- use mathematics class to interpret and display the data they gather through experiments performed in science class
- use science class to make solutions whose concentrations correspond to ratios studied in mathematics class.

SOCIAL STUDIES

Through current affairs, students will develop an awareness of potential problems related to the use of certain solutions and mixtures in the local community:

- personal safety hazards
- disposal problems
- environmental concerns.

Social studies students might use comparative mapping activities to consider the advantages/disadvantages of using particular mixtures and solutions that are studied in science class.

PRACTICAL ARTS

Solutions and mixtures are frequently used in the workplace. Within the practical arts program, students are given opportunities to develop appropriate strategies for handling, storing and disposing of mixtures/solutions used in work-related situations.

Conferencing among science and practical arts teachers will assist in identifying mixtures/solutions for study in science that are used by students in their practical arts classes. These mixtures/solutions may include:

- cleaning fluids
- lubricating fluids
- cooking/baking ingredients
- beverages
- paints
- child care products.

COMMUNITY PARTNERSHIP OPPORTUNITIES

- Invite a paramedic or fire chief to discuss the hazards/safe handling and storage techniques for potentially dangerous products found in the home.

- Invite a local pharmacist to discuss the properties of mixtures and solutions used in personal care products.

- Invite a representative from the hair care, dry cleaning, automotive, agricultural or paint industry to discuss the properties of mixtures and solutions used in their respective service areas.

- Visit a local paint store and investigate the mixing of paints. Ask store personnel to explain:
  - the use of different solvents in the manufacture of paints
  - appropriate thinning/cleaning strategies for water- and oil-based paints
  - how paints are tinted/coloured.

- Visit a local automotive shop. Ask a mechanic or other knowledgeable person to explain the use of various solutions in maintaining a vehicle (e.g., antifreeze, windshield washing fluid, lock de-icer, lubricants).

- Invite a representative from a company selling water softeners to explain principles governing the operation of a water softener. (e.g., How does this device "soften" hard water?)

- Visit local stores in an attempt to gather information provided on the labels of familiar household products (e.g., hazardous chemical symbols, product ingredients, directions for use, recovery techniques for errors in handling).

- Visit a community water purification facility and observe solutions/filtration techniques being used.

- Invite an environmentalist to speak to the class about environmental problems that have resulted from the use of certain solutions/mixtures. Discuss related concerns that are both local and global in nature (e.g., smog, acid rain, oil spills).

BASIC RESOURCE CORRELATION

Science Plus Technology and Society 8
- Unit: Solutions

SUGGESTED ACTIVITIES

Science Plus Technology and Society 8 and its corresponding *Teacher Resource Book* provide a variety of activity-based investigations that support the learning objectives identified in this theme. The activities that follow may be used to supplement those provided in the basic learning resource. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

Recognizes the properties of familiar household solutions and mixtures.

1. Brainstorm a list of as many household solutions and mixtures as possible. Design a chart that can be used to describe the properties and uses of the substances identified.

CLARIFICATION/EXAMPLE

SOLUTION/MIXTURE	PROPERTIES	USES

The attribute guide provided in The Nature of Science, "Strategies for Developing the Inquiry Skills", will assist students to structure their observations and describe the properties of familiar solutions/mixtures.

2. Visit a local grocery store/hardware store/pharmacy. Gather information on various solutions and mixtures that are sold. Create a bulletin board display that illustrates the properties and uses of these mixtures/solutions.

LEARNING OBJECTIVE

Distinguishes between solutions and non-solutions.

1. Provide opportunities for students to distinguish between solutions and non-solutions by performing the experiments provided in Resource 1: Solutions and Mixtures.

   While performing these experiment, encourage students to recognize that:

   - most solutions are transparent mixtures
   - the parts of a solution are spread uniformly through one another
   - the particles which make up the parts of a solution are too small to be seen with the naked eye or an ordinary microscope
   - no true solution shows the Tyndall Effect.

   A variety of strategies that will assist students to develop and use inquiry skills appropriate to these investigations are provided in The Nature of Science, "Strategies for Developing the Inquiry Skills".

2. Place students in groups of two. Ask each group of students to:

   - prepare a non-poisonous mystery mixture
   - exchange their mystery mixture with another group
   - describe the properties of the mystery mixture
   - identify the mystery mixture as a solution or a non-solution.

   Encourage each group of students to share the results of their investigations with the class.

LEARNING OBJECTIVE

Gives familiar examples of solutions that are composed of: – solid and gas – gas and liquid – liquid and liquid – solid and solid – gas and gas.

1. Identify solutions used around the home. Classify the solutions as mixtures of solid and gas, gas and liquid, liquid and liquid, solid and solid or gas and gas. Record results in a table.

CLARIFICATION/EXAMPLE

SOLUTION	SOLID AND GAS	GAS AND LIQUID	LIQUID AND LIQUID	SOLID AND SOLID	GAS AND GAS
soda pop	✓				
brass				✓	
water		✓			

2. Demonstrate, or provide opportunities for students to investigate the phenomena described in Resource 2: Gas Dissolved in a Liquid.

   Encourage students to make accurate observations and draw appropriate conclusions through questioning techniques similar to those described in The Nature of Science, "Questioning/ Defining the Problem".

LEARNING OBJECTIVE

Demonstrates an understanding of techniques used to:
- **separate mixtures**
- **recover solutes from a solution.**

1. Provide students with four test tubes that contain the following substances:

   - Tube One: cooking oil and water
   - Tube Two: water
   - Tube Three: sand and water
   - Tube Four: salt water

   Ask students to identify each substance as a mixture or a solution. Devise strategies that will enable students to:

   - separate mixtures
   - recover solutes from solutions.

2. Investigate real life applications of techniques used to separate mixtures and recover solutes from solutions.
   e.g., – the salt mining process
   – the distillation of crude oil.

   Conduct research and report findings using strategies provided in Communication Skills, "Reading and Viewing Science Materials" and "Summarizing, Evaluating and Communicating Ideas in Science".

3. Discuss the following statement:

   "People cannot drink salt water, but icebergs that form in salt water can be used for drinking water".

   Design an investigation that will explain how this is possible. Use strategies provided in The Nature of Science, "A Model for Scientific Inquiry".

LEARNING OBJECTIVE

Distinguishes between the properties/uses of household solutions that:
- **are water-based**
- **contain solvents other than water.**

1. Identify solutions found in the kitchen, laundry room or workshop that are water-based, and others that have non-water bases. Compare the properties and uses of these solutions on the basis of the solvents they contain. Record the information in a chart.

2. Create, within the science classroom, a display of familiar household solutions. Group and label the solutions according to the type of solvents they contain.
   e.g., – water-based
   – alcohol-based
   – oil-based.

   The local pharmacist or hardware store clerk may be able to identify solutions that contain a variety of different solvents.

3. Explain why water is often called the "universal solvent". Ask students to identify situations that would disprove this statement.

LEARNING OBJECTIVE

Identifies factors/conditions that affect the solubility of materials:
- **temperature**
- **choice of solvent.**

1. Obtain two bottles of a carbonated beverage. Refrigerate one bottle until cold and let the other bottle sit at room temperature. Open the bottles and compare the amount of gas that escapes from each. Write a short paragraph that will describe and explain your observations.

2. Prepare some hot tea and some iced tea. Add sugar, one teaspoon at a time, to each liquid.

   - How many teaspoons of sugar can be dissolved in each type of tea?
   - What effect does temperature have on the solubility of sugar in the tea?

3. Use knowledge of factors affecting solubility to explain a variety of natural phenomena.
   e.g., Why do fish often die during periods of hot weather?

4. Identify a variety of familiar substances that are insoluble in water. Suggest other solvents that may be effective in dissolving these substances.

e.g.,	Substance	Solvent
	grease	methyl alcohol
	nail polish	ethyl acetate
	oil paint	turpentine

LEARNING OBJECTIVE

Identifies factors/conditions that affect speed of dissolving:
- **temperature**
- **particle size**
- **mechanical movement.**

1. Determine the mass of one cube of sugar. Measure out an equal mass of granular sugar. Place the cube of sugar and the granular sugar in separate beakers, each containing one cup of water. Allow each beaker to sit at room temperature. Record the time taken for each portion of sugar to dissolve in the water.

2. Repeat the procedure described in Activity 1. This time, however, stir the sugar and water in each beaker. Record the time taken for each portion of sugar to dissolve in the water.

3. Repeat the procedure described in Activity 1. This time, however, boil the water. Record the time required for each portion of sugar to dissolve in the water.

4. Prepare a graph that illustrates the results of activities 1, 2 and 3. Predict the effects of temperature, particle size and mechanical movement on rate of dissolving.

5. Perform the experiment described in Resource 3: Volume Changes of Solute and Solvent.

   A variety of strategies that will assist students to develop and use inquiry skills that are appropriate to this investigation are provided in The Nature of Science, "Strategies for Developing the Inquiry Skills".

LEARNING OBJECTIVE

Distinguishes between dilute, concentrated and saturated solutions.

1. Develop an understanding of the concepts of dilute, concentrated and saturated solutions by conducting the investigation described in Resource 4: Unsaturated, Saturated and Supersaturated Solutions.

Strategies provided in Communication Skills, "Giving and Following Directions", will assist students to perform the sequential activities outlined in this investigation.

2. Research the technological processes involved in manufacturing:

   - fruit juices
   - dairy products.

   Discuss the use of dilute, concentrated and saturated solutions in these processes. Describe each process by using the skeletal outlines and idea diagrams provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

3. Encourage students to apply related concepts by providing opportunities for students to make:

   - a dilute, concentrated and saturated fruit juice
   - a dairy product.

LEARNING OBJECTIVE

Describes the effect of the strength of a solution on its freezing/boiling point.

1. Obtain three beakers and approximately 60 mL of sugar. Label the beakers A, B and C. Then follow the directions outlined below.

   Step One: Boil 200 mL of water in beaker A. Record the time required to boil the water and the temperature of the boiling water. Then place the beaker in a freezer. Record the time required for ice crystals to form on the surface of the water and the temperature at which they form.

   Step Two: Add 20 mL of sugar to 200 mL of water in Beaker B. Record the time required to boil the solution and the temperature of the boiling solution. Then place the beaker in the freezer. Record the time required for ice crystals to form on the surface of the solution and the temperature at which they form.

   Step Three: Add 40 mL of sugar to 200 mL water in Beaker C. Then repeat the procedure described in Step 2.

   Construct graphs that illustrate:

   - the results of this investigation
   - the effect of the strength of a solution on its freezing/boiling point.

2. Use the results of activity 1 (above) to explain:

   - the effect of salt on a slippery sidewalk
   - why syrups/sauces take longer to boil than water
   - the use of antifreeze in the cooling system of an automobile
   - the use of salt in raising cooking temperatures.

LEARNING OBJECTIVE

Demonstrates crystal formation through the use of super-saturated solutions.

1. Prepare a saturated solution of sugar and a super-saturated solution of sugar. Add several crystals of sugar to each solution. Predict which solution will form more crystals. Observe crystal formation in each solution over a period of time. Explain why there is a difference in the rate of crystal formation within each solution.

2. Provide opportunities for students to grow and examine crystals through the use of activities provided in Resource 5: Crystal Growing.

   Structure student observation of crystal formation through the use of an attribute guide. A sample attribute guide is provided in The Nature of Science, "Strategies for Developing the Inquiry Skills".

3. Develop and reinforce vocabulary related to mixtures and solutions. Effective vocabulary development activities are provided in Communication Skills, "Developing Technical Vocabulary".

RESOURCE 1: SOLUTIONS AND MIXTURES

OBJECT To distinguish between solutions and mixtures.

APPARATUS
- 3 test tubes
- test tube rack
- rubber stoppers
- funnel
- filmstrip projector
- magnifying glass
- teaspoon

SUPPLIES
- powdered milk
- copper sulfate
- garden soil
- filter paper

PROCEDURE

1. Half-fill each of the three test tubes with water.
2. Add a teaspoon of powdered milk to one test tube, a teaspoon of copper sulphate to another test tube, and a teaspoon of garden soil to the third test tube.
3. Stopper the tubes and shake them.
4. Examine each mixture with a magnifying glass. Look for individual particles in each mixture.
5. Darken the room. Hold each mixture in a beam of light emitted from a filmstrip projector. Note whether any of the mixtures scatter light.
6. Note whether any of the mixtures show signs of settling.
7. Try to filter each of the mixtures.

OBSERVATIONS

1. Describe what you observed with the magnifying glass and with the projector.

_____

_____

_____

_____

2. Describe what you observed in steps 6 and 7.

_____

_____

_____

_____

CONCLUSIONS

On the basis of your observations and what you know about the properties of a solution, decide which mixture(s) may correctly be called a solution. State your reasons.

_____

_____

_____

_____

_____

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RESOURCE 2: GAS DISSOLVED IN A LIQUID

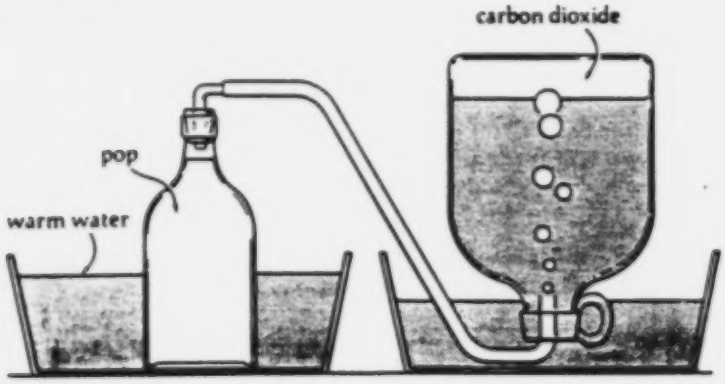
OBJECT To remove the gas from a bottle of carbonated pop.

APPARATUS
2 dishpans
large bottle/jug
single-hole rubber stopper
rubber tubing
glass elbow

SUPPLIES 450 mL bottle of carbonated pop

PROCEDURE

1. Listen carefully as you remove the cap from an ice-cold bottle of carbonated pop.
2. Insert a stopper connected to a hose into the bottle.
3. Lead the other end of the hose into the neck of a large, inverted bottle that is full of water.
4. Place the bottle of pop in a pan or pail of warm water. Gradually increase the temperature of the water in the pan/pail by adding boiling water from a kettle. The process may be speeded up by gently shaking the bottle.
5. Disconnect the hoses and taste the pop that is left in the pop bottle.



OBSERVATION

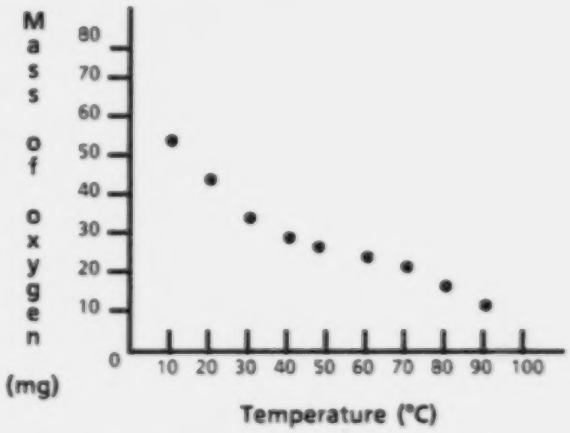
Record your observations from steps 1, 4 and 5.

CONCLUSIONS

1. How does air pressure affect the amount of gas that is dissolved in carbonated pop?

2. Will water dissolve more gas or less gas when it is warmed. How does this compare with the effect of a rise in temperature on the ability of a liquid to dissolve a solid?

3. Examine the graph. How many milligrams of oxygen will dissolve in 1L of water at 10°C? If the temperature of the water is raised to 30°C, how much oxygen will dissolve in it?



This graph illustrates the mass of oxygen dissolved in 1 L of water at different temperatures.

4. A new manufacturing plant is constructed beside a small river. Water at 15°C is pumped from the river and used in the plant to cool various engines. It is then poured back into the river at 70°C. What effect will this have on the oxygen content of the water downstream from the plant? How might this affect aquatic life?

RESOURCE 2: GAS DISSOLVED IN A LIQUID (continued)

5. Scuba divers, who have been exploring at considerable depths, are careful not to surface too quickly so as to avoid the "bends". This is a condition that arises when nitrogen bubbles develop in the bloodstream. Explain why the bubbles form.

6. Why does soda pop fizz when shaken?

7. A student fills an aquarium with cold water. After an hour, bubbles appear on the glass. Explain why this happens.

8. a. What factors affect the speed with which solids dissolve?

   b. What factors affect the speed with which gases dissolve?

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RESOURCE 3: VOLUME CHANGES OF SOLUTE AND SOLVENT

OBJECT To determine what happens to the volume of the solute and the solvent.

APPARATUS
graduated cylinder
beaker

SUPPLIES
50 mL sugar
50 mL water
50 mL alcohol
popsicle stick

PROCEDURE

1. Measure 50 mL of water in the graduated cylinder and pour it into the beaker.
2. Measure 50 mL of alcohol in the graduated cylinder.
3. Pour the alcohol into the water. Give it time to mix.
4. Carefully read the volume of the solution.
5. Repeat steps 1 to 4, dissolving 50 mL of sugar in 50 mL of water.

OBSERVATION

Record your readings from steps 4 and 5.

_____

_____

_____

_____

CONCLUSION

1. What conclusion can you draw from this investigation?

_____

_____

_____

_____

_____

RESOURCE 3: VOLUME CHANGES OF SOLUTE AND SOLVENT (continued)

2. Granules of sugar have air spaces between them. Could these spaces account entirely for the decrease in volume that you observed?

3. Can you suggest what else may have caused a decrease in volume?

4. Did the mass change as well as the volume? Explain your answer.

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RESOURCE 4: UNSATURATED, SATURATED, AND SUPER-SATURATED SOLUTIONS

OBJECT To determine how unsaturated, saturated, and super-saturated solutions are made.

APPARATUS
balance
test tube (20 mm X 150 mm)
beaker
test tube holder
hot plate

SUPPLIES
popsicle stick
15 g sodium thiosulphate ("hypo") crystals
distilled water

PROCEDURE

1. Pour distilled water into a test tube to a depth of about 1 cm.
2. Using the balance, measure 15 g of hypo.
3. Place three crystals of hypo in the test tube and stir until they dissolve. This is an unsaturated solution.
4. Add hypo crystals, one at a time, stirring until each crystal dissolves. Stop adding crystals when they no longer dissolve. This is a saturated solution.
5. Gently warm the solution over the hot plate. Add a few more crystals, one at a time, making sure they dissolve completely.
6. Cool the solution by placing it in a beaker partially filled with cold tap water. The solution is now super-saturated, since it contains more hypo than would normally dissolve at the lower temperature.
7. Drop one small crystal of hypo into the super-saturated solution, and observe what happens. This is called "seeding".
8. Lift the test tube from the cold bath just after the hypo crystals have formed. Feel the test tube with your hand.

OBSERVATIONS

Describe what you observed in steps 5, 7 and 8.

RESOURCE 4: UNSATURATED, SATURATED, AND SUPER-SATURATES SOLUTIONS (continued)

CONCLUSION

1. How did you know that the solution, after the addition of only a few hypo crystals, was unsaturated?

2. How did you know when you had succeeded in making a saturated solution?

3. What was the effect of warming the saturated solution?

4. How did you know you had made a super-saturated solution?

5. If you were given a solution in a test tube, how would you use one or two crystals of the solute to determine whether the solution was unsaturated, saturated or super-saturated?

6. Where did the heat come from in step 8?

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RESOURCE 5: CRYSTAL GROWING

OBJECTIVE To grow bluestone crystals.

APPARATUS
test tube
balance
graduated cylinder
test tube holder
magnifying glass
hot plate
overhead projector

SUPPLIES
popsicle stick
copper sulphate
water

PROCEDURE

1. Measure out 5 g of copper sulphate.
2. Put the copper sulphate in the test tube and add 10 mL of water.
3. Heat and stir until the copper sulphate has dissolved.
4. Let the solution cool slowly to near room temperature.
5. Add a small seed crystal (if crystals have not already appeared).
6. Examine the crystals with the help of a magnifying glass. Pour off the remaining solution. Carefully remove the crystals from the test tube for closer examination.
7. Double or triple the amounts of copper sulphate and water indicated in steps 1 and 2, and use a beaker instead of a test tube. When you are ready to add a seed crystal, place the beaker on an overhead projector. Watch the crystals grow on the screen.

OBSERVATIONS

1. Sketch and describe the crystals you made.

_____

_____

_____

2. Describe what you observed as the crystals grew.

_____

_____

_____

RESOURCE 5: CRYSTAL GROWING (continued)

CONCLUSION

1. What type of solution was formed:

   a. when all the solute had dissolved?

   _____

   _____

   _____

   b. when the solution had cooled?

   _____

   _____

   _____

   c. after the crystals had stopped growing?

   _____

   _____

   _____

2. How do you think the arrangement of the particles in a solution differs from their arrangement in a crystal? Draw diagrams to show the two arrangements.

   _____

   _____

   _____

   _____

   _____

   _____

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THEME C

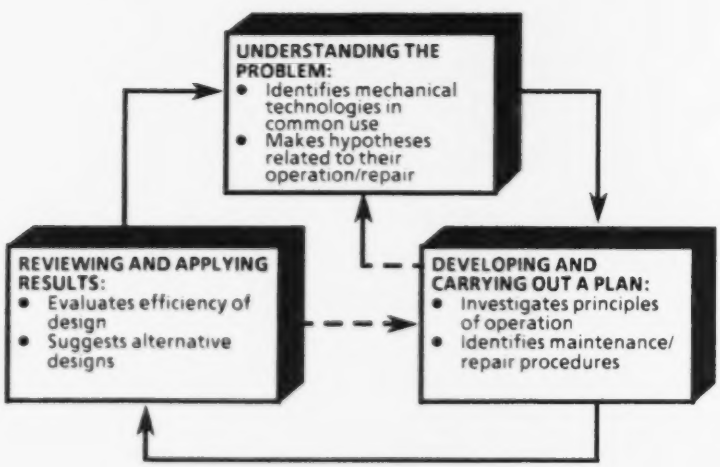
USING ENERGY AND MACHINES

Technology makes use of our energy sources in mechanical systems that are frequently used by students in the home and the community. Investigations undertaken will focus attention on the scientific principles that govern the operation of simple machines and more sophisticated mechanical systems. Students will gain experience in the actual construction and repair of simple mechanical technologies. Activities that demonstrate our dependence on energy systems and the need to manage our energy resources will enable students to become increasingly "energy wise".

Teachers are encouraged to reference the "Generic Strategies" provided in this manual when planning for instruction. Strategies particularly relevant to the learning objectives and activities outlined in this theme can be found in:

- The Relationship Between Science and Technology
- Communication Skills
- Evaluation.

A MODEL FOR SOLVING TECHNOLOGICAL PROBLEMS


UNDERSTANDING THE PROBLEM:
• Identifies mechanical technologies in common use
• Makes hypotheses related to their operation/repair
DEVELOPING AND CARRYING OUT A PLAN:
• Investigates principles of operation
• Identifies maintenance/ repair procedures
REVIEWING AND APPLYING RESULTS:
• Evaluates efficiency of design
• Suggests alternative designs

CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

- Explains the relation between force, motion, work and energy in real life situations.
- Recognizes how the forces of gravity and friction affect work that is accomplished.
- Demonstrates, through the use of simple labour saving devices, how simple machines help us to do work:
  - transfer of energy
  - increasing/decreasing speed
  - changing direction of force
  - increasing/decreasing force.
- Recognizes how combinations of simple machines are used in familiar mechanical systems and technologies to change direction/speed/magnitude of force.
- Identifies major sources/forms of energy used to power mechanical systems:
  - chemical
  - mechanical
  - heat
  - electrical.
- Recognizes that, in doing work, machines transfer energy from one form to another, and that useful energy is often lost in the form of heat.
- Describes energy flow/transformation/efficiency in familiar mechanical systems.
- Distinguishes between renewable and non-renewable sources of energy.
- Recognizes the rapid rate at which non-renewable sources of energy are being used by society, and the need to conserve these sources of energy.

SKILLS

- Measures force/mass/distance, using units, tools and procedures that are appropriate to the task being performed.
- Calculates work done in accomplishing simple tasks (e.g., lifting or moving an object).
- Performs experiments with the lever, inclined plane, pulley and pulley system, demonstrating ability to:
  - manipulate materials
  - measure
  - collect and report data
  - interpret data
  - draw conclusions.
- Performs simple calculations required in developing an understanding of concepts related to:
  - mechanical advantage
  - work input/output
  - efficiency.
- Analyzes familiar tools/labour saving devices/mechanical systems, identifying:
  - sub-systems
  - component parts
  - energy flow.

SKILLS (continued)

- Identifies ways to improve the efficiency of simple mechanical systems by:
  - lessening frictional losses
  - improving the design.
- Applies problem-solving skills in troubleshooting mechanical systems containing relatively few components:
  - identifies the source of the problem
  - considers alternative approaches to a solution
  - evaluates alternatives and makes necessary repairs.
- Constructs/invents a simple mechanical device intended to perform a given function.
- Constructs energy chains that trace forms of energy used in machines back to their original source.

ATTITUDES

- Displays a positive attitude toward self and the study of science:
  - assumes responsibility for personal conduct
  - performs investigations and completes assignments independently and in cooperation with others
  - practises strategies for resolving interpersonal conflict
  - shows interest and curiosity through willingness to ask questions/share observations and ideas/seek answers.
- Appreciates the usefulness of technological problem-solving skills in finding solutions to practical problems.
- Demonstrates confidence in personal ability to solve practical problems.
- Realizes the relationship between science and familiar machine technologies.
- Appreciates the extent to which science and machine technology have influenced and changed our society.
- Display responsible attitudes toward energy consumption as it relates to personal and global needs.

INTEGRATION ACTIVITIES

LANGUAGE ARTS

Students will use a variety of communication skills throughout activities in this theme. Instructional activities will require students to:

- give and follow directions when planning and performing investigations
- use comprehension skills when processing and analyzing data obtained through investigation/experimentation
- use critical/creative thinking skills when inventing and constructing a simple mechanical device.

Teachers are encouraged to identify appropriate strategies for developing these skills through cooperative conferencing with teachers of language arts. Strategies for developing communication skills frequently used in science are also provided in the "Communication Skills" section of this manual. Learning activities intended to develop an understanding of the relationship between science and technology may involve research and writing activities that can be integrated with the language arts program.

MATHEMATICS

Students will use a variety of mathematical skills in gathering and interpreting data. Mathematical skills may include:

- measuring force/mass/distance
- writing/manipulating ratios and proportions
- interpreting algebraic sentences (formulas) that describe scientific phenomena.

Cooperative planning will provide opportunities for students to apply mathematical skills that have been learned in scientific contexts. Scientific data and relationships studied in science class might be organized/analyzed through the use of numbers and algebraic symbols in mathematics class.

SOCIAL STUDIES

Students will develop an awareness of current energy issues through activities in current affairs. Cooperative planning between the science and social studies teachers might provide opportunities for students to investigate a current energy concern, its impact on our province/country and possible alternatives/solutions to the issue.

The social studies program will also provide opportunities for students to:

- recognize the impact of mechanical technologies upon the social/economic structure of Alberta/Canada
- recognize changes in job trends caused by the development of labour saving devices.

PRACTICAL ARTS

Thematic concepts/skills can be reinforced throughout the practical arts program. Provide opportunities for students to analyze the mechanical technologies they use within the practical arts program by:

- identifying the scientific principles that govern their operation
- developing appropriate strategies for using/maintaining/repairing these technologies.

Encourage students to recognize occupational/entrepreneurial opportunities that are related to maintenance and repair of mechanical technologies.

COMMUNITY PARTNERSHIP OPPORTUNITIES

- Visit a local business/industry. Observe the use of machine technologies on the job. Make a list of machines being used and identify the scientific principles that govern the operation of these machines.

- Visit a local power generating plant or a farm with a windmill. Note mechanical systems that are being used, and energy transformation/conservation.

- Visit a solar efficient building and note energy transformation/conservation.

- Invite a representative from the local electrical/natural gas utility company to discuss energy consumption/conservation practices in the home.

- Invite a local mechanic, carpenter or other tradesperson to discuss the applications made of energy and machines in their work, and the need for regular maintenance and repair of mechanical technologies.

- Invite a doctor/nurse to discuss the muscular and skeletal systems of the human body, and how these systems may function like simple machines.

- Invite an engineer/environmentalist to discuss issues that relate to local energy supply and use.

- Ask a local paramedic/fireman to demonstrate principles governing the operation of the "jaws of life". Identify the similarities/differences between this technology and familiar simple machines.

- Arrange visits/interviews with scientists and engineers. Distinguish between the nature of the work performed by scientists and engineers. Discuss the contributions made by Canadian scientists and engineers to the fields of science and technology (e.g., the arm for the NASA space shuttle).

- Visit a local farm and observe the use of machine technologies. Discuss changes that have occurred in the farming industry as a result of developments in science and technology.

- Interview several senior citizens. Ask them to describe ways in which society has changed over the last 30-50 years as a result of developments in machine technology.

BASIC RESOURCE CORRELATION

Science Plus Technology and Society 8
- Unit: Work, Energy and Machines

SUGGESTED ACTIVITIES

Science Plus Technology and Society 8 and its corresponding *Teacher Resource Book* provide a variety of activity-based investigations that support the learning objectives identified in this theme. The activities that follow may be used to supplement those provided in the basic learning resource. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

Explains the relation between force, motion, work and energy in real life situations.

1. Develop an understanding of the scientific meaning of force, motion, work and energy through the use of strategies similar to those provided in Communication Skills, "Developing Technical Vocabulary".

   e.g., - Vocabulary Self-Collection Strategy
   - Teacher Interaction Technique
   - Vocabulary Sorting.

2. Discuss and debate the following statements:

   - "Holding a stack of books involves work."
   - "Studying for an exam is not a form of work."

   Structures discussion and debate using the strategies provided in Communication Skills, "Strategies for Discussing and Debating"

3. Provide opportunities for students to analyze a variety of real life situations in terms of work that is accomplished in a scientific context.

   - playing the piano
   - climbing a tree
   - holding a 24 kilogram bag of concrete without moving
   - a dam holding back a lake of water
   - a pillar holding up a ceiling

4. Ask students to determine the amount of work (if any) that is accomplished in climbing a flight of stairs. Encourage students to focus attention on the factors (e.g., force, motion) that are essential to the scientific idea of work.

5. Suppose that in a tug-of-war, two teams are equally matched. Although each team pulled the rope for many minutes, neither team was able to move it. Ask students to determine whether work was accomplished in this situation, and to provide reasons for their answer.

LEARNING OBJECTIVE

Recognizes how the forces of gravity and friction affect work that is accomplished.

1. Identify ways in which the forces of gravity and friction act together to influence work that is accomplished in the following situations:

   - driving a car up a hill
   - cycling up a hill
   - building pyramids in ancient history.

   Encourage students to predict what might happen if the forces of gravity and friction were not present in these and other real life situations.

2. Ask students to explain how the forces of gravity and friction affect work that is accomplished when a pile driver strikes an object. Compare/contrast this situation to one where a meteorite strikes the surface of the earth.

3. Investigate the effects of gravity and friction on the take-off and re-entry of a rocket through our atmosphere. Describe various ways in which technology compensates for the forces of gravity and friction in rocket design.

4. Research principles governing the operation of the luge and bobsleigh machines. Invite an athlete or other knowledgeable person to explain how friction and gravity affect the design and operation of these machines.

LEARNING OBJECTIVE

Demonstrates, through the use of simple labour saving devices, how simple machines help us to do work:

- **transfer of energy**
- **increasing/decreasing speed**
- **changing direction of force**
- **increasing/decreasing force.**

1. Display a variety of familiar household tools (e.g., crowbar, wrench, screwdriver, nutcracker, scissors, pliers, tongs, hammer, tweezers). Ask students to:

   - describe the function of these tools
   - identify similarities/differences between the tools
   - explain how they assist humans to do work.

2. Brainstorm examples of familiar machines (simple or complex) that:

   - transfer energy from one place to another
   - increase/decrease force, distance or speed
   - change the direction of a force

   Investigate basic principles governing the operation of these machines, and describe:

   - their advantages/disadvantages
   - factors affecting their efficiency

3. Demonstrate how simple machines can be used to increase force through the use of a first-class lever:

   - ask students to lift one side of a piece of furniture so as to develop an appreciation of its weight
   - assemble a simple lever that might be used to lift the same piece of furniture. Position the fulcrum at various positions along the lever
   - compare the force required to lift the piece of furniture using the lever to the force required without using the lever

   Ask students to identify applications of the lever that are found in their homes.

4. Demonstrate how an inclined plane is used to minimize effort when lifting heavy objects:

   - lift a heavy object from floor to table
   - construct a ramp, and move the same object from floor to table by sliding/rolling the object up the ramp
   - discuss the advantages/disadvantages of moving the object with the ramp

   Explain how the wedge, screw and chisel are applications of the inclined plane.

5. Provide each student with a piece of twine, a brick and several pulleys. Ask students to devise a method of lifting the brick from the floor to the table using one or more pulleys. Encourage students to identify the advantages/disadvantages of their pulley system when compared to those devised by other members of the class.

6. Investigate the use of various "prostheses" in extending the physical capabilities of an individual. Discuss the application of simple machines in the construction/operation of these devices.

LEARNING OBJECTIVE

Recognizes how combinations of simple machines are used in familiar mechanical systems and technologies to change direction/speed/magnitude of force.

1. Examine component parts of a bicycle. Discuss how each part contributes to the functioning of this mechanical system.

   e.g., - legs (which are really levers)
   - peddles (which are a wheel and axle)
   - gears (which are pulleys)

   Encourage students to recognize how several simple machines work together in a bicycle to transfer energy, produce change in the direction of force, and increase force and speed.

Perform similar investigations with other mechanical systems frequently used in real life:

- alarm clock
- sewing machine
- construction crane
- fishing rod
- hand-held can opener
- pencil sharpener

2. Encourage students to recognize the relationship between science and technology. Provide opportunities for students to:

   - identify familiar technologies whose operation are governed by the scientific concepts being studied
   - identify scientific concepts that govern the operation of familiar technologies.

   Strategies that may be useful in developing an understanding of these relationships are provided in The Relationship Between Science and Technology, "Understanding Science and Technology".

3. Students should recognize that mechanical technologies are developed in response to the wants/needs of individuals and society. Provide opportunities for students to design/construct mechanical systems that serve given functions. Discuss alternative designs suggested by students. Evaluate technologies by considering their usefulness/efficiency.

   Activities that may assist students to design and construct a mechanical system are provided in The Relationship Between Science and Technology, "A Model for Technological Problem Solving".

LEARNING OBJECTIVE

Identifies major sources/forms of energy used to power mechanical systems:

- **chemical**
- **mechanical**
- **heat**
- **electrical.**

1. Collect pictures and articles that illustrate/describe different sources/forms of energy used to power mechanical systems. Design a bulletin board display of these energy sources. Write a descriptive paragraph for each picture/article. Structure writing activities by using strategies provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

2. Ask students to identify familiar technologies that are powered by chemical/mechanical/thermal/electrical energy. Trace energy flow and transformation within each of these technological systems.

3. Invite a guest speaker from a local utility company (e.g., electric, natural gas) to discuss the use of thermal and electrical energy in powering mechanical technologies.

LEARNING OBJECTIVE

Recognizes that in doing work, machines transfer energy from one form to another, and that useful energy is often lost in the form of heat.

1. Through brainstorming, identify examples of potential and kinetic energy. Make a poster that provides illustrations of each kind of energy.

2. Provide opportunities for students to experience the conversion of mechanical energy into heat energy.

   e.g., – Bend a coat hanger back and forth several times. Feel the spot that was bent with your fingers.
   – Warm a bottle of water/sand by shaking it. Measure the temperature of the water/sand both before and after shaking the bottle.

3. Analyze the energy input, conversion and output components in familiar mechanical systems (e.g., bicycle, sewing machine, construction crane). Identify and describe:

   - the form of energy used to drive the machine (i.e., energy input)
   - the form of energy produced by the machine (i.e., energy output)
   - the energy transformation/conversion process (i.e., what happened between energy input and energy output).

   Discuss major sources of energy loss (e.g., friction, heat) within these mechanical systems. Identify strategies/techniques that might be effective in reducing energy loss within each system.

LEARNING OBJECTIVE

Describes energy flow/transformation/efficiency in familiar mechanical systems.

1. Demonstrate energy flow/transformation by:

   - rolling a ball across the floor. Ask students to suggest factors that may have caused the ball to stop rolling.
   - dropping a ball on the floor and allowing it to bounce one time. Ask students to describe energy transformation as the ball drops and bounces back up.

2. Devise a simple energy system that demonstrates the conservation of energy.

   e.g., A windmill uses the wind's kinetic energy to pump water uphill into storage tanks or reservoirs. The water can then be made to flow downhill through large turbines to generate electrical energy.

   Illustrate the energy system through diagrams, and provide an opportunity for students to construct a model of the system.

3. Analyze energy transformations that occur in several sports. Encourage students to:

   - describe the energy transformations that occur
   - suggest ways to improve the efficiency of specific movements
   - identify physical traits that may improve an individual's ability to perform

4. Discuss efficiency as the ratio of output energy in a mechanical system to its input energy. Compare and contrast the overall efficiency of:

   - a pulley system with an inclined plane
   - a bicycle with a wheelchair
   - a large car with a small car

   Ask students to suggest reasons why simple machines may be more efficient than complex machines.

LEARNING OBJECTIVE

Distinguishes between renewable and non-renewable sources of energy.

1. Ask students to explain why:

   - hydro, solar and wind energy are considered to be renewable resources
   - fossil fuels are considered to be non-renewable resources.

2. Collect pictures and words from newspapers/magazines that illustrate:

   - renewable energy resources
   - non-renewable energy resources

   Make a poster or bulletin board display that depicts how various renewable and non-renewable energy sources are used in our everyday lives.

3. Identify, on a map of Alberta, areas where renewable and non-renewable energy resources are found. Ask students to gather information on one renewable energy resource and one non-renewable energy resource by writing letters to locations identified on the map of Alberta.

4. Research recent developments in science and technology that may be effective in providing new sources of energy to power our machines:

   - fusion
   - geothermal energy
   - solar cells.

LEARNING OBJECTIVE

Recognizes the rapid rate at which non-renewable sources of energy are being used by society, and the need to conserve these sources of energy.

1. Provide opportunities for students to develop an awareness of the impact of non-renewable sources of energy on their lives. Ask students to monitor their activities for a day, and record/describe the ways in which they use energy derived from non-renewable sources.

Additional activities that will enable students to recognize their dependence on energy systems are provided in The Relationship Between Science and Technology, "Understanding Science and Technology".

2. Identify one or more non-renewable energy resources for which supply and environmental impact are of current concern.

e.g., fossil fuels:
- diminishing supply
- acid rain
- greenhouse effect
- oil spills

Investigate some alternatives to the use of the non-renewable energy resource identified above.

e.g., - solar energy
- geothermal energy
- wind energy
- nuclear energy

Evaluate alternative energy sources by considering the potential advantages/disadvantages of each source of energy relative to its:

- availability
- impact on the environment
- usefulness.

When evaluating alternative energy sources, encourage students to organize and structure their thought processes through the use of strategies provided in Communication Skills, "Using Critical Thinking Skills".

3. Encourage students to express their opinion on current energy issues of local relevance through informal writing projects. Such projects should foster students' ability to:

- formulate an opinion/action plan
- provide detail that supports a point of view.

A variety of pre-writing activities that will assist students to plan and organize their thoughts are provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

THEME D

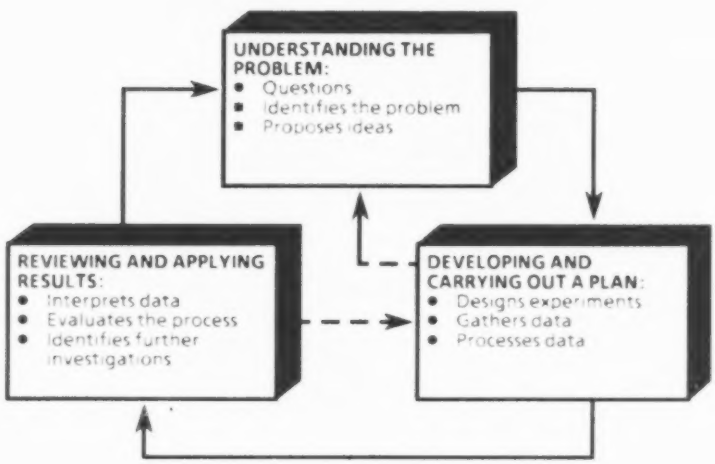
GROWING PLANTS

This topic will develop a strategy for monitoring and managing plant growth. By conducting a series of controlled experiments, students will gain first-hand knowledge of factors that contribute to the nourishment and care of familiar home and garden plants. Opportunity will be provided for students to investigate and use various technologies designed to enhance plant growth and yield. Activities should focus attention on the extent to which human actions and interventions have affected the variety, distribution and growth of plants found in the local environment.

Teachers are encouraged to reference the "Generic Strategies" provided in this manual when planning for instruction. Strategies particularly relevant to the learning objectives and activities outlined in this theme can be found in:

- The Nature of Science
- The Relationship Between Science and Technology
- Communication Skills
- Evaluation.

A MODEL FOR CONDUCTING SCIENTIFIC INQUIRY



CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

- Recognizes the importance of plants as basic producers of food.
- Describes how energy for all living things is provided through the process of photosynthesis.
- Identifies general characteristics and specializations in the structure of vascular plants:
  - leaf
  - stem
  - root
  - flower.
- Recognizes that living plants function as the sum total of their structural systems and the life processes they perform:
  - osmosis
  - conduction
  - transpiration
  - photosynthesis
  - reproduction.
- Demonstrates an understanding of the ways in which plants reproduce in natural and specialized environments:
  - propagation by vegetative reproduction
  - flowering and seeds.
- Describes how specialized varieties of plants are developed through programs of controlled breeding.
- Identifies essential natural requirements for germination and plant growth.
- Recognizes how technology may be used to create specialized environments that maximize plant growth:
  - fertilization/growth supplements
  - aeration
  - liming
  - hydroponics
  - pesticides/herbicides.
- Identifies symptoms of plant stress that may be caused by an imbalance in essential growth requirements, or by plant diseases and pests.
- Recognizes biological and chemical methods of controlling plant diseases and pests.

SKILLS

- Observes/identifies local vascular plants.
- Gathers information related to the structure of vascular plants:
  - observes and infers the function of major plant structures (e g , leaf, stem, root, flower)
  - uses a microscope to observe the cellular structure of plants
  - dissects flowers, identifying individual parts and their function.
- Observes and infers the life processes of plants (e g , osmosis, conduction, transpiration, gas exchange, photosynthesis, reproduction).
- Constructs/interprets charts that indicate the results of selective breeding and cross-breeding.

SKILLS (continued)

- Uses appropriate inquiry skills, demonstrating ability to:
  - manipulate materials
  - follow safe procedures for handling laboratory equipment and materials
  - accurately observe and measure
  - identify and control variables
  - infer relationships between variables
  - hypothesize and make predictions.
- Performs experiments that monitor the effect of variations in growth conditions on plant development and growth:
  - manipulates light/soil/moisture conditions
  - tests soils used for pH
  - compares the use of different fertilizers/growth supplements
  - uses hydroponic solutions.
- Propagates plants through methods of vegetative reproduction and from seeds.
- Demonstrates a knowledge of plant-care procedures by growing a healthy plant:
  - monitors supply of essential requirements for growth
  - diagnoses health/growth problems
  - corrects problems that are diagnosed
  - maintains a growth record from germination to flowering, noting care procedures followed.
- Uses decision-making skills in order to evaluate the effects of familiar technologies in plant science on the local environment.

ATTITUDES

- Displays a positive attitude toward self and the study of science:
  - assumes responsibility for personal conduct
  - performs investigations and completes assignments independently and in cooperation with others
  - practises strategies for resolving interpersonal conflict
  - shows interest and curiosity through willingness to ask questions/share observations and ideas/seek answers.
- Appreciates the role of plants in sustaining human life.
- Realizes that the distribution and growth of plants is very much affected by technology and society through environmental modifications and human interventions.
- Realizes that agricultural and domestic varieties of plants are usually the products of intensive breeding programs.
- Demonstrates, through discussion and personal action, a respect for living things and a commitment to protecting the environment.
- Displays confidence in personal ability to nurture plants.

INTEGRATION ACTIVITIES

LANGUAGE ARTS

Students will use a variety of communication skills throughout activities in this theme. Instructional activities will require students to:

- develop technical vocabulary related to the structure/growth/care of plants
- give and follow directions when designing/conducting investigations
- use viewing/reporting/note-making skills when gathering, organizing and communicating information related to the growth of plants.

Teachers are encouraged to identify appropriate strategies for developing these skills through cooperative conferencing with teachers of language arts. Strategies for developing related skills are also provided in the "Communication Skills" section of this manual.

MATHEMATICS

Students will be using skills developed in mathematics class. They:

- measure mass/capacity/temperature/time
- interpret/generate equivalent ratios
- classify and display data in table/chart form
- interpret graphs.

Science teachers are encouraged to conference with the mathematics teacher in establishing appropriate strategies for applying mathematical concepts/skills. Plan activities that will enable students to use mathematics class to interpret and display the data they gather through experiments performed in science.

SOCIAL STUDIES

Students will develop an awareness of the importance of vegetation in the local environment. Science and social studies classes may wish to undertake a landscaping project in the school yard or local community that involves obtaining and planting trees, shrubs and other plants. Social studies students might obtain funding/nursery specimens for the project from local government agencies and businesses. Science students could then plant and provide care for the nursery stock.

Through their study of Mexico/Brazil, social studies students might compare and contrast:

- plant varieties native to Canada and Mexico/Brazil
- technologies used to maximize plant growth in Canada and Mexico/Brazil.

PRACTICAL ARTS

Students will research employment opportunities in the areas of horticulture and agriculture. Conferencing among science and practical arts teachers will assist in identifying thematic concepts/skills that have application in the students' practical arts program.

COMMUNITY PARTNERSHIP OPPORTUNITIES

- Interview a home economist (or home economics teacher). Ask this person to discuss essential nutrients/minerals that are provided by common edible plants.

- Visit a local farm and observe the types of crops that are grown. Ask a farmer to explain:
  - why particular crops are grown
  - the need for crop rotation
  - the use of fertilizers/growth supplements/pesticides
  - the method(s) of plant propagation that are used.

  This field trip might be planned in the spring or fall when planting/harvesting can be observed.

- Visit a local greenhouse to observe the propagation of plants by vegetative reproduction and through the use of seeds. Ask the horticulturalist to explain how specialized varieties of plants are developed through controlled breeding programs.

- Visit a local plant store. Ask the the proprietor to discuss strategies used in caring for house/garden plants:
  - watering routines
  - use of growth supplements/fertilizers
  - symptoms of plant stress
  - control of pests.

- Invite a plant-care specialist to speak to the class about strategies used to:
  - monitor the supply of essential requirements for plant growth
  - diagnose health/growth problems in plants
  - correct health/growth problems in plants.

- Invite a district agriculturalist/horticulturalist to explain how plant breeding programs have developed specialized plant varieties (e.g., grains, trees, grasses, garden plants) that are suited to the local area. This person might also discuss the importance of aerating/fertilizing/pruning in facilitating plant growth.

- Invite a representative from a fertilizer/pesticide company to speak to the class about the use of chemical fertilizers and pesticides. Ask this person to discuss strategies for determining:
  - product ingredients (e.g., 10-10-10 fertilizer)
  - appropriate application techniques.

- Investigate different soil types found in the local environment. Notice the micro-environment surrounding each type of soil.

- Invite an agriculturalist or other informed person to discuss local practices with respect to:
  - soil analysis
  - fertilizer use
  - control of plant disease.

- Visit a local greenhouse/nursery/farm. Make a list of technologies that are used to maximize plant growth and yield.

- Interview a local resident who can describe changes that have occurred in the distribution/growth of plants found in the surrounding area over the last decade.

- Invite a government representative to discuss:
  - laws/regulations that control the import of plants/plant materials into Canada
  - the success of these laws/regulations in controlling the spread of plant diseases and pests.

- Plan a walking trip through the local area. Identify the variety of plants observed. Compare/contrast the root, stem, leaf and flower structure of local plants.

BASIC RESOURCE CORRELATION

Science Plus Technology and Society 8
- Unit: Growing Plants

SUGGESTED ACTIVITIES

Science Plus Technology and Society 8 and its corresponding *Teacher Resource Book* provide a variety of activity-based investigations that support the learning objectives identified in this theme. The activities that follow may be used to supplement those provided in the basic learning resource. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

Recognizes the importance of plants as basic producers of food.

1. Make a collage of pictures from books and magazines that illustrate plant and animal life. Discuss the scenes and find support for the premise that plants are the basic producers of food.

2. Identify a variety of familiar food products. Construct a chart that will indicate the name of the plant from which each food product is produced, the part of the plant used in producing the food product, and where the plant is grown.

   CLARIFICATION/EXAMPLE

FOOD PRODUCT	PLANT SOURCE	PLANT STRUCTURE	WHERE GROWN
flour	wheat	seed	Alberta

3. Visit local gardens, farms, greenhouses, pulp mills, florists and grain elevators. Identify and discuss the variety of ways in which plants affect society:

   - food
   - employment
   - ecology
   - aesthetic beauty

4. Brainstorm a list of local animals. Construct food chains/webs that trace the energy source for each animal back to plants (e.g., cats → mice → grain)

LEARNING OBJECTIVE

Describes how energy for all living things is provided through the process of photosynthesis.

1. Discuss the importance of sunlight and photosynthesis in providing energy for all living things. Trace the source of various forms of energy back to plants and the sun through the use of the diagram provided in Resource 1: Where Do You Get All That Energy?

2. Investigate the food production process in plants. Obtain a geranium plant and perform the experiment outlined in the steps that follow.

   a. Place the plant in darkness for several days prior to the experiment to stop the food production process.
   b. Remove the plant from darkness. Cut small initials out of aluminum foil or black construction paper. Paper clip the initials to a leaf of the geranium and place it in the sun for three days.
   c. Remove the initials and place the leaf in a beaker of hot alcohol for two minutes in order to remove the green colour.
   d. Place the leaf in a second bath of hot water for two minutes.
   e. Place the leaf in a beaker of alcohol at room temperature and shake for three to four minutes in order to dissolve any chlorophyll that is present.
   f. Place the leaf on a paper towel. Test for starch by placing iodine on the leaf with an eyedropper. The presence of starch in the leaf should cause the iodine to turn a blue/black colour.
   g. Record your observations.

   Discuss the results of the investigation by asking students to:

   - compare what happened in parts of the leaf exposed to sunlight with parts of the leaf not exposed to sunlight.
   - identify the product produced in the leaf.
   - describe the process that occurred in the leaf.
   - explain the role of sunlight in producing food in plants.

LEARNING OBJECTIVE

Identifies general characteristics and specializations in the structure of vascular plants:
- **leaf**
- **stem**
- **root**
- **flower.**

1. Collect a variety of plant specimens with roots intact (e.g., dandelion, grass, wheat). Wash the roots very gently under water. Lay each plant upon a sheet of poster paper and tack or tape it into position. Compare/contrast the parts of each plant. Describe the structural specializations and adaptations that are unique to each plant.

2. Encourage students to bring a variety of plants to school, and ask them to organize/classify the plants according to:

   - leaf structure/arrangement
   - stem structure
   - root structure
   - flower structure/arrangement

   Ask students to provide reasons for their classification scheme. Research the unique specializations/adaptations of each plant grouping.

3. Visit a field or park that contains some dense tree growth. Ask students to collect/dig, at random, some common plants, keeping roots intact, along a straight line transact from the field into the trees. Label the plants that have been collected and bring them back to class for observation. Dry and mount the plants on poster paper in the same sequence as they were collected along the transact. Observe diversities between those plants collected in the open field and those collected amidst dense tree growth. Suggest reasons for these diversifications in plant structure.

4. Identify several different biomes in the world. Choose one or more plants unique to each area. Investigate how each plant has a specialized vascular structure that enables it to live in that biome. Display the results of investigation on a bulletin board.

5. Obtain potted tulips, wood sorrel or a prayer plant. Observe the changes that occur in the leaves and stems of these plants through the day and night.

6. Observe the structure/growth of roots and root hairs by placing radish or bean seeds inside a glass that is lined with a moist paper towel. Place the seeds between the glass and the paper towel. Fill the glass with damp towels to insure that the seeds remain moist and firmly secured along the side of the glass. With a magnifying glass, observe the roots of the seedlings as they develop each day. Record observations.

   Once roots and root hairs are well developed, plant the seedlings in soil and carefully observe further growth and maturation of the plants. Monitor and record plant growth, using charts and diagrams.

7. Obtain a cross-section of a log or tree. Sand or plane the cross-sectional surface until it is smooth. Determine the age of the tree by counting the rings of growth. Suggest reasons for variations in the:

   - size of the rings
   - spaces between the rings.

8. Grow dwarf tomato seeds in class. As the tomato plants begin to flower, use a magnifying glass to observe flower structure and development. Carefully remove a flower and observe it under a microscope. Record observations through the use of diagrams.

9. Obtain several different kinds of flowers (e.g., garden or potted flowers, florist's discards). Carefully dissect each flower. Identify each part of the flower and its function. Mount and label the parts of each flower on poster paper.

10. Soak bean seeds in water overnight. After soaking the seeds, carefully split several seeds in half. Identify the seed coat, cotyledons (seed leaves), radicle (root), and plumule (stem leaves). Plant extra seeds along the side of a glass container and observe the germination process. Record observations through the use of sketches/diagrams.

LEARNING OBJECTIVE

Recognizes that living plants function as the sum total of their structural systems and the life processes they perform:
- **osmosis**
- **conduction**
- **transpiration**
- **photosynthesis**
- **reproduction.**

1. Provide opportunity for students to investigate osmosis by performing the experiment outlined below:

   a. Obtain two 250 mL beakers. Label as Beaker A (Control) and Beaker B (Experiment).
   b. Fill each beaker with water. Place a healthy plant cutting in each beaker.
   c. Add 15 mL of salt to Beaker B (Experiment).
   d. Observe the results the next day.

2. Demonstrate conduction in plants by placing a celery stalk in a glass of coloured water. Monitor water movement through the stalk over a period of several hours.

3. Demonstrate transpiration in plants by placing a healthy plant inside a clear plastic bag. Seal the plastic bag and place it in the sunshine or under a lamp for several hours. Observe the formation of water droplets inside the plastic bag.

4. Research the process of photosynthesis, using strategies provided in Communication Skills, "Reading and Viewing Science Materials." Encourage students to recognize how photosynthesis:

   - depends upon other structural systems and life processes within the plant. (e.g., osmosis, conduction, transpiration)
   - is affected by change in seasons.
   - produces food not only for the plant, but for all living things.

5. Research and draw diagrams of the:

   - nitrogen cycle
   - mineral cycle
   - water cycle
   - oxygen/carbon dioxide cycle.

   Through discussion, encourage students to recognize the importance of these cycles in sustaining essential life processes in plants.

LEARNING OBJECTIVE

Demonstrates an understanding of the ways in which plants reproduce in natural and specialized environments:
- **propagation by vegetative reproduction**
- **flowering and seeds.**

1. Provide opportunities for students to grow plants using:

   - various methods of vegetative propagation (e.g., leaf/stem cuttings, runners, bulbs, tubers, corms)
   - different kinds of seeds.

   Encourage students to observe and chart the growth of each plant.

   Identify several local plants of economic/aesthetic importance that are propagated by each method.

2. Discuss the following statement:

   "Many plants would become extinct if it were not for their unique methods of seed dispersal."

   Collect a variety of seed specimens or pictures of seeds. Carefully examine each seed, and identify specializations that ensure survival of the plant species. Ask students to describe at least five methods used by plants to disperse their seeds.

3. Investigate the processes of pollination, fertilization and seed production by performing the following investigation:

   a. Select several well-developed flowers on a potted specimen or garden plant (e.g., sweet pea, tomato). Examine the reproductive organs of each flower with a hand lens.
   b. Using a fine, dry sterilized brush, gently remove the pollen from the stamen of one flower and lightly brush it over the stigma of another flower.
   c. Cover the pollinated flower organs. Over a two-week period, observe changes that take place in the ovary, and the development of fruit.
   d. When the fruit is mature, gather the seeds and allow them to dry.

   Encourage students to record their observations throughout this investigation, using strategies provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

LEARNING OBJECTIVE

Describes how specialized varieties of plants are developed through programs of controlled breeding.

1. Invite a district agriculturalist/horticulturalist to explain how plant breeding programs have developed specialized plant varieties that are suited to the local area.
   e.g., - grains
   - trees/shrubs
   - garden vegetables
   - grasses

2. Visit a university/college facility/nursery farm. Investigate techniques used to develop specialized varieties of plants that are suited to Alberta's climate and weather conditions. Summarize and display gathered information on a bulletin board.

3. Discuss the ways in which science and technology have contributed to the development of specialized plant varieties. Provide opportunities for students to research:

   - controlled plant breeding programs
   - genetic engineering in plants.

   A variety of strategies that will assist students to summarize and communicate the information they gather are provided in Communication Skills, "Reading and Viewing Science Materials" and "Summarizing, Evaluating and Communicating Ideas in Science".

LEARNING OBJECTIVE

Identifies essential natural requirements for germination and plant growth.

1. Provide opportunities for students to design/conduct experiments in which they compare the growth of plants under controlled conditions of:

   - light
   - heat
   - moisture
   - soil.

   Strategies that may assist students to design/conduct experiments are provided in The Nature of Science, "Strategies for Developing the Inquiry Skills".

2. Simulate situations in which one or more of the essential requirements for plant growth are removed. Record the effects of these conditions on plant health.
   e.g., - Grow seeds in two trays of vermiculite. Water one tray with tap water and the other tray with distilled water.
   - Encase the root of a carrot plant in plastic or paraffin wax. Replant and observe the plant's reactions.
   - Remove all the leaves from a bean plant and observe what happens.
   - Place a plant in darkness for several days and observe the effects of this environment on the plant.
   - Cover the lower sides of the leaves of a bean plant with vaseline. Observe the plant's reactions.

3. Perform the experiment described in Resource 2: Essential Conditions for Germination and Growth.

   Coach students in the use of inquiry skills appropriate to this investigation. (see The Nature of Science, "Strategies for Developing the Inquiry Skills")

LEARNING OBJECTIVE

Recognizes how technology may be used to create specialized environments that maximize plant growth:
- **fertilization/growth supplements**
- **aeration**
- **liming**
- **hydroponics**
- **pesticides/herbicides.**

1. Provide opportunities for students to grow plant specimens, using different types of fertilizer/growth supplements. Observe differences in plant growth. Construct graphs/charts that illustrate differences in plant growth.

2. Visit a local greenhouse/nursery/agricultural facility. Tour the facility and observe the use of various technologies (e.g., fertilization, growth supplements, aeration, liming, pesticides) in maximizing plant growth.

   Invite a district agriculturalist/horticulturalist to class. Discuss the advantages/disadvantages of using various technologies to facilitate plant growth.

3. Investigate the use of hydroponics in growing gardening plants. Try growing vegetables/herbs in a solution of water and hydroponic chemicals. Gently anchor stem cuttings in a layer of sterilized gravel, and place in a window or under a grow lamp.

   Research the advantages/disadvantages of producing vegetables through the use of hydroponics.

4. Conduct a classroom debate:

   "Government legislation should require that chemical fertilizers be replaced with organic fertilizers".

   Structure the debate using suggestions provided in Communication Skills, "Strategies for Discussing and Debating".

LEARNING OBJECTIVE

Identifies symptoms of plant stress that may be caused by an imbalance in essential growth requirements, or by plant diseases and pests.

1. Identify and discuss causes of plant stress:

   - soil/moisture conditions
   - temperature/light conditions
   - deficiencies in nitrogen, potassium, phosphorous and other trace elements
   - plant diseases and pests

   Prepare posters that illustrate plant stress symptoms, their cause, and strategies for correcting the imbalance.

2. Through brainstorming, make a list of essential requirements for the growth of healthy plants. Develop a "care strategy" for plants that will ensure an appropriate supply of essential growth requirements. The care strategy may take the form of a list of "do's" and "do not's".

3. Ask students to complete the exercises on plant care provided in Resource 3: Caring for Plants.

4. Visit a local "plant hospital". Identify and discuss:

   - various types of plant stress
   - care strategies used to remedy each type of plant stress

LEARNING OBJECTIVE

Recognizes biological and chemical methods of controlling plant diseases and pests.

1 Research the life cycle of the spruce budworm and its effect on spruce tree populations. Evaluate the long-term and short-term effects of biological and chemical methods used to control the spruce budworm.

Guide students through the process of analysis and critical thought, using strategies provided in Communication Skills, "Using Critical Thinking Skills".

2 Gather information about various insecticides, fungicides and herbicides used in the local community. In a chart, record information that is gathered providing:

- the commercial name of the product
- a description of the product's properties (e.g., liquid, powder, solid)
- application procedures
- precautionary/safety measures

Provide opportunities for students to identify and interpret the hazardous chemical symbols used on pesticides. Make posters that display these symbols and the messages they convey.

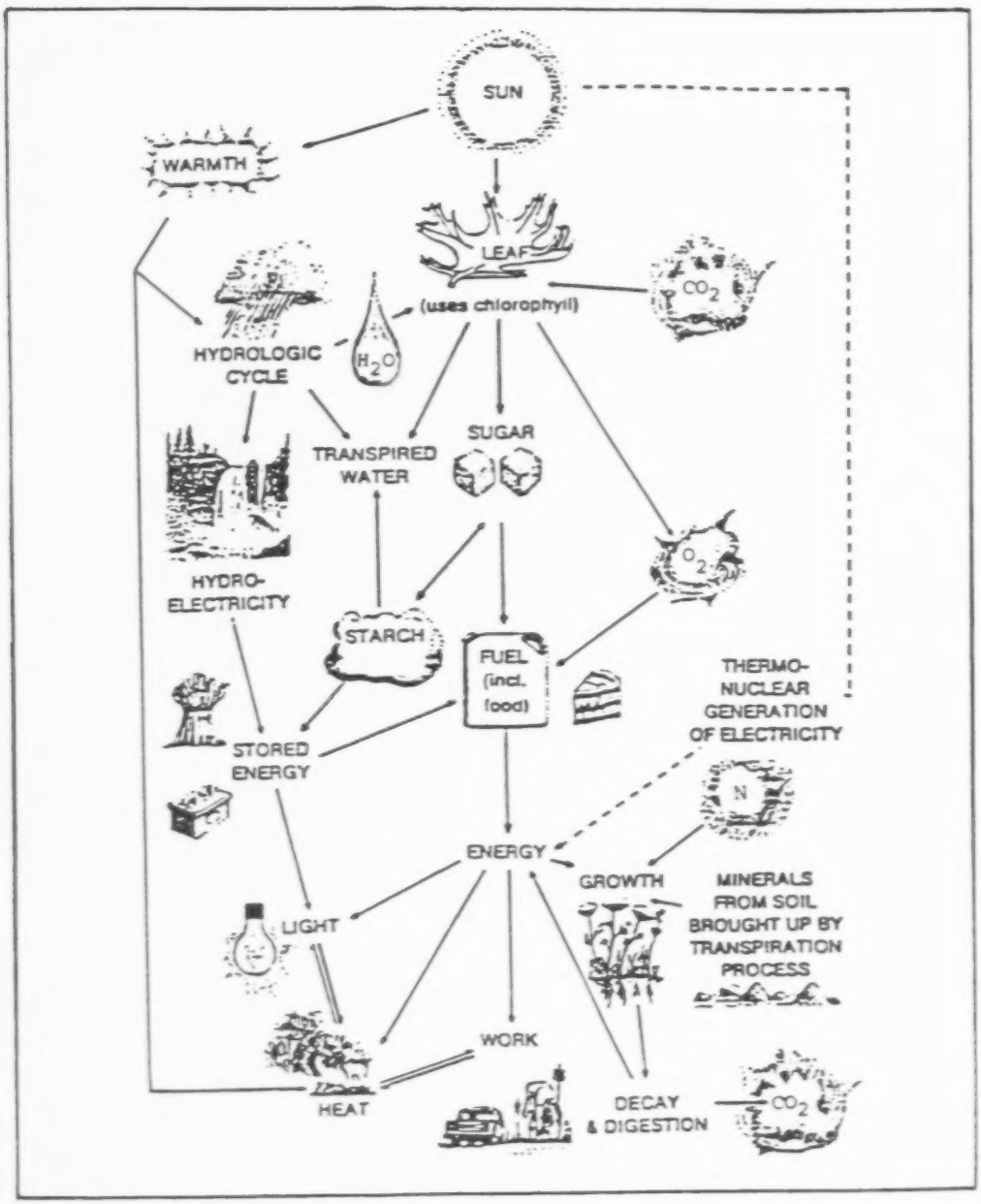
3 Conduct a classroom debate on the pros and cons of aerial spraying forests and agricultural crops.

Structure the debate using the suggestions provided in Communication Skills, "Strategies for Discussing and Debating".

4 Invite a district agriculturalist/horticulturalist to discuss biological methods of controlling plant diseases and pests.

Encourage students to consider the advantages/disadvantages of biological methods of control as compared to chemical methods of control.

RESOURCE 1: WHERE DO YOU GET ALL THAT ENERGY?



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RESOURCE 2: ESSENTIAL CONDITIONS FOR GERMINATION AND GROWTH

OBJECT

To study the conditions necessary for a seed to germinate.

APPARATUS

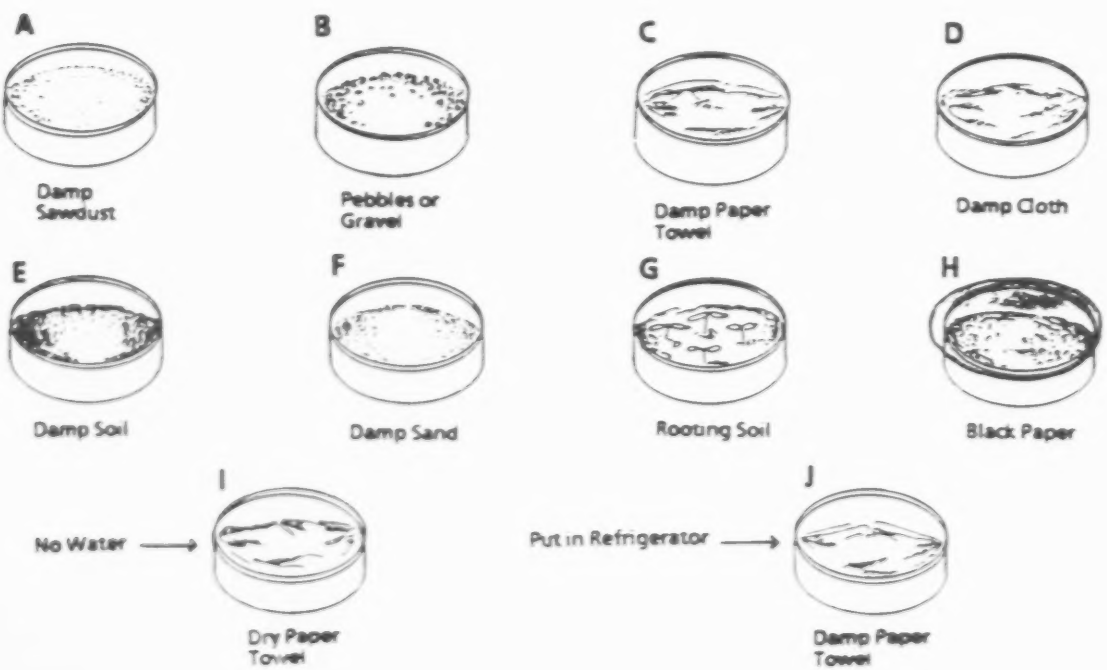
cooler or refrigerator
garden flat and cover
10 small starter pots

SUPPLIES

damp sawdust
damp paper towels
dry paper towels
damp cloth
damp soil
damp sand
black paper
water
pebbles or gravel
20 tomato seeds

PROCEDURE

1. Label each of the ten starter pots with your name, class, date and the letters from A to J.
2. Set up each of the starter pots as illustrated in the diagram. Be sure to use the correct potting mixture.



RESOURCE 2: ESSENTIAL CONDITIONS FOR GERMINATION AND GROWTH (continued)

3. Place two seeds in each pot. Cover them lightly with the potting medium of that container.

4. Gently sprinkle pots A, B, C, D, E, F, and G with warm water and put them in a garden flat. Cover the flat with a tight fitting lid to keep the starter pots moist. Place the flat on a shelf.

5. Place paper towels in the bottom of pot H. Water it enough to wet the towels. Place the seeds on the towel. Cover the pot with black paper. Seal this pot with a plastic bag to keep it moist. Put the pot on a shelf with the other pots. (It may be placed in the flat if you wish.)

6. Repeat step 5 with pot I, BUT DO NOT USE ANY WATER. Place it on the shelf beside your flat.

7. Pot J should be prepared in the same way that pot H was prepared, EXCEPT THAT IT SHOULD BE PLACED IN THE COOLER.

8. Observe the seeds in each pot on a daily basis.

OBSERVATIONS

Design a chart that lists each pot and numbers the days of observation. Enter observations in the chart each day, noting changes that occur and the germination of seeds.

CONCLUSIONS

1. Did any seeds grow in pot A?

_____

2. What can you conclude about damp sawdust as a growing medium?

_____

3. Did any seeds grow in pot B?

_____

4. What can you conclude about pebbles or gravel as a growing medium?

_____

5. Did any seeds grow in pot C?

_____

6. What can you conclude about damp paper towels as a growing medium?

_____

7. Did any seeds grow in pot D?

_____

RESOURCE 2: ESSENTIAL CONDITIONS FOR GERMINATION AND GROWTH (continued)

8. What can you conclude about damp cloth as a growing medium?

_____

9. Did any seeds grow in pot E?

_____

10. What can you conclude about damp soil as a growing medium?

_____

11. Did any seeds grow in pot F?

_____

12. What can you conclude about damp sand as a growing medium?

_____

13. Did any seeds grow in pot G?

_____

14. What can you conclude about soil as a growing medium?

_____

15. Did any seeds grow in pot H?

_____

16. Why didn't the seeds grow in darkness?

_____

17. Did any seeds grow in pot I?

_____

18. Why didn't the seeds grow without moisture?

_____

19. Did any seeds grow in pot J?

_____

20. Why didn't the seeds grow in a cool environment?

_____

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RESOURCE 3: CARING FOR PLANTS

A. Indicate whether the following statements are true or false. If the statement is true, explain why it is true. If the statement is false, rewrite it to make it true.

1 _____ House plants will adapt somewhat to environmental conditions that surround it.

_____

2 _____ Some plants demand more care and attention than others.

_____

3 _____ If you suspect that leaves are infected with disease or insect pests, washing the leaves will only spread the problem to other leaves.

_____

4 _____ Cold water can shock plants; it is better to use tepid water for watering plants.

_____

5 _____ Use mild soapy water to clean plants.

_____

6 _____ Place plants in the direct sun to dry.

_____

7 _____ Water left on the leaves for long periods of time may cause fungal rot.

_____

8 _____ Painted glossy leaves are more pleasing than naturally clean leaves.

_____

9 _____ Many leaf cleaners clog the leaf pores.

_____

10 _____ Examine plants regularly.

_____

11 _____ Water plants every day whether the plants feel dry or not.

_____

12 _____ Most plants prefer moist air.

_____

13 _____ Plants like to be placed close to windows.

_____

RESOURCE 3: CARING FOR PLANTS (continued)

14. _____ Plants must be kept clean.

15. _____ Loosen the potting soil if it becomes hard.

16. _____ Always overwater in case you forget to water your plants next week.

17. _____ You should buy plants whose leaves are a bright green colour.

18. _____ Remove dead leaves and flowers.

19. _____ Many house plants thrive when placed outside.

20. _____ Repot or redress plants with lumps of dirt.

21. _____ Overwatering is a common cause of plant stress.

22. _____ Small plants can be soil-washed in a sink if the soil is salty.

23. _____ New plants will not need fertilizer for a year.

24. _____ A tooth brush is a good tool for cleaning the leaves of plants.

25. _____ There is no need to examine your plants daily.

26. _____ Most plants prefer dry air.

27. _____ Give your plant a bath at least every two months.

28. _____ Hot water is good for plants in the cold winter months.

29. _____ Cuttings are used to start many new plants.

30. _____ Plants should be repotted after their rest period.

31. _____ It is a good practice to leave plants sitting in water for several days.

32. _____ Keep plants away from heating vents.

33. _____ Water plants according to need.

34. _____ Sun scorch is often a problem when plants are placed close to windows.

B. Complete the following statements with the correct word or words.

1. House plants will adapt somewhat to conditions of _____, _____ and _____.
2. When you examine your plants, check for:
   a. _____
   b. _____
3. Keeping plants clean will _____
4. Rotating plants a quarter of a turn each week will prevent _____
5. The appearance of a plant can be improved by:
   a. _____
   b. _____
   c. _____
   d. _____
   e. _____
6. Leaves that are not evenly green may indicate _____

THEME A

MONITORING THE LOCAL ENVIRONMENT

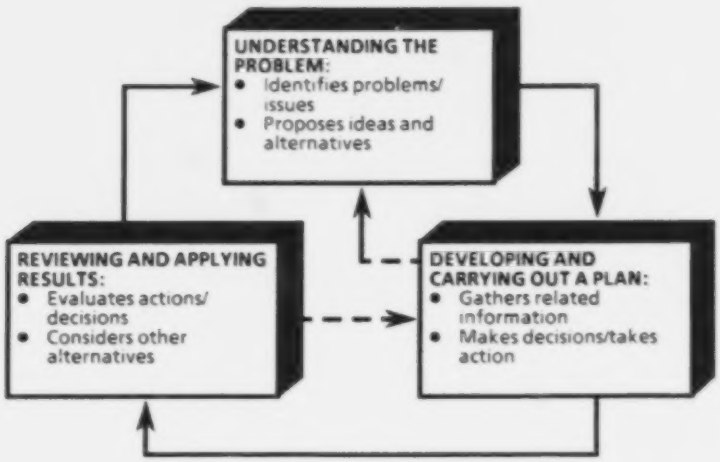
Environmental care is becoming increasingly important in our technological society. We often experience adverse environmental conditions that can be associated with liquid, gas, material and noise pollutants. The media frequently provide us with additional information on environmental issues of both local and global significance. Activities undertaken will enable students to:

- recognize the sources and effects of different types of pollution in the local environment
- perform pollution related experiments
- develop and evaluate action plans for dealing with local environmental issues.

Teachers are encouraged to reference the "Generic Strategies" provided in this manual when planning for instruction. Strategies particularly relevant to the learning objectives and activities outlined in this theme can be found in:

- The Nature of Science
- The Role of Science and Technology in Society
- Communication Skills
- Evaluation.

A MODEL FOR MAKING DECISIONS ON ENVIRONMENTAL ISSUES


UNDERSTANDING THE PROBLEM:
• Identifies problems/ issues
• Proposes ideas and alternatives
DEVELOPING AND CARRYING OUT A PLAN:
• Gathers related information
• Makes decisions/takes action
REVIEWING AND APPLYING RESULTS:
• Evaluates actions/ decisions
• Considers other alternatives

CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

- Demonstrates an understanding of concepts previously developed in Grade 8:
  - recognizes that living things interact with other living and non-living parts of the environment
  - describes the effects of non-living parts of the local environment on living organisms
  - recognizes the delicate balance that exists among living and non-living elements present in the environment.
- Identifies major forms of pollution in the local environment:
  - air pollution
  - water pollution
  - soil pollution
  - noise pollution.
- Describes local situations where human activity has altered living and non-living elements in the local environment:
  - development of a local resource
  - disposal of local waste/sewage
  - land-use practices
  - use of biocides
  - population growth.
- Describes ways in which local use of natural resources has upset ecological balance and threatens environmental quality.
- Recognizes how the use of certain technologies has created/intensified local environmental problems.
- Recognizes the value of biodegradable materials in reducing the impact of the products we use in the environment.
- Recognizes that individuals and society have the ability to monitor and manage their use of resources and environment.

SKILLS

- Selects and uses measuring instruments as required in monitoring environmental quality.
- Observes and measures non-living parts of the environment that are modified as a result of human activity:
  - temperature
  - moisture
  - light
  - pH level.
- Uses appropriate strategies to gather data related to materials that are added to the environment as a result of human activity:
  - particles carried in the air
  - solid particles carried in water
  - solid wastes generated in the home.
- Predicts/hypothesizes the effects that changes in non-living parts of the environment have on living parts of the environment.

SKILLS (continued)

- Uses inquiry skills to monitor local pollution factors (e.g., water quality, air quality, sound/noise pollution):
  - designs a plan
  - gathers and processes data
  - interprets data
  - applies data to acceptable standards.
- Uses decision-making skills to analyze a local environmental issue:
  - identifies a problem/issue related to use of the environment
  - gathers and organizes information related to the environmental issue
  - considers the perspectives and points of view of different groups within the community
  - evaluates information gathered (i.e., identifies cause and effect, predicts the effects of alternative responses to the issue)
  - chooses actions/makes decisions that minimize environmental impact
  - communicates findings and decisions verbally and through written expression.

ATTITUDES

- Displays a positive attitude toward self and the study of science:
  - assumes responsibility for personal conduct
  - performs investigations and completes assignments independently and in cooperation with others
  - practises strategies for resolving interpersonal conflict
  - shows interest and curiosity through willingness to ask questions/share observations and ideas/seek answers.
- Develops sensitivity for the delicate balance among living things and their environment.
- Shows concern for the changes in the natural environment made by technology and society.
- Demonstrates a commitment, through discussion and personal action, to protecting and improving the environment.
- Recognizes that environmental issues involve relationships among science, technology and society.
- Values the use of scientific knowledge in understanding environmental issues, and in making personal and community decisions that relate to care of the environment.

INTEGRATION ACTIVITIES

LANGUAGE ARTS

Students will use a variety of communication skills throughout activities in this theme. Activities will require students to use:

- "comprehension skills" when gathering and interpreting data about environmental issues
- "inquiry skills" when monitoring the effects of human practices on the environment
- "reporting skills" when presenting data.

Teachers are encouraged to identify appropriate strategies for developing these skills through conferencing with language arts teachers. Learning activities that develop an awareness of the role of science and technology in society may involve research and writing activities that can be integrated with the language arts program.

MATHEMATICS

Students will use a variety of mathematical skills in gathering and interpreting data throughout this theme. These skills may include:

- selecting/using appropriate units and tools of measurement
- classifying/manipulating numerical data
- reading/interpreting tables, charts and graphs
- constructing tables and charts.

Cooperative planning will provide opportunities for students to apply mathematical skills in a scientific context. Numerical data obtained in science class might be organized, interpreted and displayed in mathematical class.

SOCIAL STUDIES

Teachers may wish to integrate the investigation of a local environmental issue with a theme studied in social studies (e.g., "You and Your Social/Economic Community").

Through activities in current affairs, social studies students might:

- identify an environmental issue of local concern
- gather information about the issue
- identify government agencies involved in the issue.

Science class could then be used to:

- gather additional information about the issue through observation/interview
- analyze/evaluate the information gathered
- identify/choose possible courses of action
- consider the long term/short term effects of actions chosen.

PRACTICAL ARTS

Students will reinforce thematic concepts/skills in their practical arts programs by:

- examining alternative methods of waste disposal in the workplace
- recognizing the harmful effects of improper methods of waste disposal
- relating sanitation/disposal procedures used within the school and community to global environmental concerns
- recognizing how environmental conditions may affect health and productivity in the home, school and workplace.

COMMUNITY PARTNERSHIP OPPORTUNITIES

- Interview a long-time resident of the community who can describe ways in which human activity/pollution has changed the local environment during the last 20-50 years.

- Plan a bus/walking trip through the local area. Identify sources of pollution and observe their effect on biotic/abiotic parts of the local community.

- Research newspapers/magazines for articles on environmental issues that are relevant in the local community.

- Invite a wildlife officer, agriculturalist or forestry official to speak to students about:
  - cyclic phenomena in wildlife caused by human activity/pollution
  - strategies that will minimize the impact of human activity on natural environments.

- Interview local officials responsible for waste disposal. Evaluate local methods of waste disposal in terms of their effects on the environment. Identify alternatives that may reduce the impact of methods currently used.

- Investigate the use of recycling programs in the local area. Identify materials that are currently recycled (e.g., bottles, paper, scrap metal), and other materials that should be recycled.

- Gather samples of "litter" in the local area. Classify litter samples as:
  - biodegradable/non-biodegradable
  - recyclable/non-recyclable.

- Visit local facilities used for water purification/sewage treatment/waste disposal. Evaluate these facilities in terms of their effect on the local environment.

- Interview a wildlife officer and discuss the need for hunting and fishing regulations. Ask the officer to explain why wildlife populations may fluctuate.

- Invite an agriculturalist/horticulturist to class. Ask this person to explain how/why pH levels in the soil may be influenced by human activity and pollution.

- Perform a plant and animal census within a remote region in the local area that is not inhabited by humans. Compare this census to one taken within a region inhabited by humans. Discuss the effect of urban development on the natural environment.

- Invite local aldermen, councillors or MLA's to discuss current policy and debate relating to pollution and environmental quality.

- Invite a law enforcement officer to discuss the use of local bylaws in controlling pollution (e.g., noise bylaws, bylaws that prohibit littering). Discuss the effectiveness of existing bylaws, and consider alternative courses of action that might be taken in dealing with pollution-related issues in the community.

BASIC RESOURCE CORRELATION

Science Plus Technology and Society 9
- Unit: Environmental Quality

SUGGESTED ACTIVITIES

Science Plus Technology and Society 9 and its corresponding *Teacher Resource Book* provide a variety of activity-based investigations that support the learning objectives identified in this theme. The activities that follow may be used to supplement those provided in the basic learning resource. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

Demonstrates an understanding of concepts previous developed in Grade 8:
- **recognizes that living things interact with other living and non-living parts of the environment**
- **describes the effects of non-living parts of the local environment on living organisms**
- **recognizes the delicate balance the exists among living and non-living elements present in the environment.**

1. Identify biotic (living) and abiotic (non-living) parts of the local environment. Provide opportunities for students to observe and describe:
   - interactions that occur among living and non-living parts of the local environment
   - the effects of these interactions on local populations of living things.

   A variety of related activities are provided in the Grade 8 theme, "Interacting With Our Environment".

2. Investigate local food chains. Illustrate how a number of food chains may intermesh to form a food web. Draw diagrams or make posters that depict relationships between food chains and food webs.

   Ask questions that will encourage students to use their knowledge of environmental factors/interactions in recognizing cause and effect relationships and in making predictions.

   e.g., – What may happen to a food chain/web when one member becomes abundant or scarce?
   – How might abiotic factors affect a food chain?
   – What factors affect the size of a given population?

   Strategies that may be useful in formulating questions, in identifying cause and effect relationships and in making predictions are provided in The Nature of Science, "Strategies for Developing the Inquiry Skills".

3. Describe a simple 3-step or 4-step food pyramid. Identify the source of energy, and energy flow at each level in the pyramid. Draw and label a diagram of the "energy cycle".

4. Discuss the following statement:

> "When one part of the natural environment is altered or changed, other biotic/abiotic parts are also affected."

Encourage students to identify ways in which human activities have altered and changed the local environment, and to infer the effects of these changes on plants and animals. Structure discussion using guidelines provided in Communication Skills, "Strategies for Discussing and Debating".

5. Identify ways in which natural phenomena may affect balance among living and non-living factors present in the environment:

- floods
- forest fires
- drought.

LEARNING OBJECTIVE

Identifies major forms of pollution in the local environment:
- **air pollution**
- **water pollution**
- **soil pollution**
- **noise pollution.**

1. Identify various sources of pollution in the local community. Classify the pollutants according to their effect on the environment.

e.g.,

Air Pollution	Water Pollution
smoking	acid rain
biocides	industrial run-off
nuclear testing	chemical disposal
automobile exhaust	sewage
Soil Pollution	**Noise Pollution**
acid rain	industrial machines
garbage/litter	stereos
biocides	aircraft
industrial refuse	vehicles/boats/motor cycles

Prepare a bulletin board display on pollution in the local community. Include articles/pictures from newspapers and magazines that discuss/illustrate:

- the sources of local pollutants
- evidence of the effects of local pollutants on personal health and the natural environment.

2. Ask and assist students to design and conduct simple experiments that monitor local pollution factors.

   e.g., – Coat several slides with petroleum jelly. Place the slides in different outdoor locations for several days. Examine the slides under a microscope and note air pollutants that have collected on the petroleum jelly.

   – Gather different water samples (e.g., rainwater, well water, water from a local stream/lake/river). Compare the acidity of water samples by measuring pH level.

   Guidelines that may help students to plan and structure their investigations are provided in The Nature of Science, "Strategies for Developing the Inquiry Skills".

3. Investigate noise pollution in the local area. Record in a chart the information that is gathered, describing:

   - various sources of noise pollution
   - the effects of noise pollution on personal health and the environment
   - local bylaws/regulations intended to control noise pollution
   - alternative strategies that may be effective in reducing noise pollution.

4. Research environmental issues of both local and global significance that have been caused by pollution.

   e.g., – oil spills
   – acid rain
   – greenhouse effect

   Structure related writing activities, using suggestions provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

LEARNING OBJECTIVE

Describes local situations where human activity has altered living and non-living elements of the local environment :
- **development of a local resource**
- **disposal of local waste/sewage**
- **land-use practices**
- **use of biocides**
- **population growth.**

1. Identify a variety of biocides that are used locally. Evaluate the use of these biocides by considering their long-term and short-term effects on the environment. Guide students through the process of critical thought, using strategies provided in Communication Skills, "Using Critical Thinking Skills".

   Collect media reports of environmental/health problems associated with the use of biocides. Identify alternatives to the use of biocides in controlling pests. Provide opportunity for students to conduct a debate:

   "Natural methods of controlling plant pests versus chemical methods of controlling plant pests".

Structure debate, using the guidelines provided in Communication Skills, "Strategies for Discussing and Debating".

2. Evaluate local methods of waste disposal by considering their effect on biotic/abiotic parts of the local environment.

   e.g., - open dumping
   - incineration
   - sanitary landfill
   - salvage
   - pulverization/compaction.

   Identify alternative strategies for disposing of solid wastes that may reduce the environmental impact of methods currently being used.

   Investigate the disposal of toxic waste materials. Collect and discuss media reports on issues associated with the disposal of toxic wastes. Does your community have a system for disposing of toxic wastes?

3. Identify problems and formulate questions related to:

   - the development of an industry on a local waterway
   - the development of a recreational facility in a wilderness area
   - local methods of sewage disposal
   - deforestation in the local area
   - local farming/land-use practices.

   Discuss both long-term and short-term effects of these developments/practices on personal health factors and the environment.

4. Discuss the following statement:

   "Humans frequently change biotic/abiotic parts of their environment to suit their own needs and wants."

   Ask an environmentalist/wildlife officer to explain how human activities may affect:

   - balance among biotic and abiotic parts of the environment
   - the size of wildlife populations.

LEARNING OBJECTIVE

Describes ways in which local use of natural resources has upset ecological balance and threatens environmental quality.

1. Research the development of a resource within the local community (e.g., hydro-electric plant, coal mine, petroleum recovery project). Use several different strategies to obtain and interpret information about the project.

e.g., - interviews/guest speakers
- field trips
- surveys
- semantic webs/flow charts.

Evaluate the development of this resource by considering its effects on:

- physical parts of the environment
- local plant and animal populations
- human populations.

Identify alternative strategies that might have reduced the harmful effects of this project on the local environment.

2. Invite a wildlife officer or biologist to explain how local use of natural resources may upset ecological balance and cause:

- cyclic phenomena in wildlife
- certain species to become endangered.

3. Provide opportunity for students to discuss the following statement:

> "Many laws have been established that make it illegal to hunt certain animals due to the season or threat of extinction. Yet humans frequently destroy the habitats of animals and upset balance in the ecosystem when they build new roads and recreational facilities in wilderness areas."

Structure discussion using strategies provided in Communication Skills, "Strategies for Discussing and Debating".

LEARNING OBJECTIVE

Recognizes how the use of certain technologies has created/intensified local environmental problems.

1. Products of science and technology are often accepted and used by society before the full extent of benefits/problems resulting from their use can be fully known. Identify environmental problems/issues of local significance that have been caused by developments in science and technology. Formulate questions related to the problems/issues that are identified, and consider alternative courses of action for dealing with these issues in the local community.

e.g., - acid rain
- radioactive fallout
- destruction of the ozone layer
- greenhouse effect
- predator extermination programs
- urban development
- use of biocides.

Strategies that will assist students to recognize how science and technology may influence societal issues have been provided in The Role of Science and Technology in Society, "Interactions Among Science, Technology and Society".

2. Research the effect of chemical "mutagens" on personal health and the environment. Identify hazardous substances in the local environment that may cause mutations in living organisms. Investigate government testing programs that are designed to control the manufacture and use of mutagenic materials.

3. Discuss the following statement:

   "Developments in science and technology have contributed to many beneficial changes in society since prehistoric times. Science and technology have also created threats to our health through various products/processes that have been developed."

   Structure discussion using suggestions provided in Communication Skills, "Strategies for Discussing and Debating".

   Identify changes in society that have occurred as a result of developments in science and technology. Use the activities provided in The Role of Science and Technology in Society, "Recognizing How Science and Technology Influence Society".

4. Ask students to express their opinions on environmental issues through informal writing projects. These projects should emphasize the ability to:

   - elaborate on an opinion/point of view
   - provide detail that supports a point of view.

   Suggestions for writing and evaluating an informal essay of this nature are provided in Communication Skills, "Informal Essay Writing".

LEARNING OBJECTIVE

Recognizes the value of biodegradable materials in reducing the impact of the products we use in the environment.

1. Distinguish between "biodegradable" and "non-biodegradable" materials. Provide opportunities for students to:

   - identify materials/pollutants of each type
   - consider appropriate strategies for disposing of each type of material.

2. Collect samples of biodegradable materials frequently used at home, at school and in the local community. Make a collage/bulletin board display, using samples that are collected.

3. Conduct a class discussion/debate on the following topic:

   "The pros and cons of using 'disposable' products."

   Throughout discussion and debate, encourage students to:

   - recognize the value of biodegradable materials in our "throw away" society
   - consider alternatives that may reduce the impact of the materials we use on the environment.

   Structure discussion and debate using suggestions provided in Communication Skills, "Strategies for Discussing and Debating".

4. Provide an opportunity for students to research recent developments in "biotechnology". Investigate how the processes/products of biotechnology are used in manufacturing consumer items that are biodegradable.

   Structure research activities using strategies provided in Communication Skills, "Reading and Viewing Science Materials".

LEARNING OBJECTIVE

Recognizes that individuals and society have the ability to monitor and manage their use of resources and environment.

1. Conduct independent/group research on conservation programs/practices that are followed within the local community.

   e.g., – use of biodegradable products
   – soil conservation practices
   – stocking/restocking lakes with fish
   – hunting/fishing regulations
   – forestry regulations
   – protection of endangered species.

   Encourage students to gather information by using local community resources (i.e., guest speakers, field trips, books/pamphlets available from local wildlife and environmental agencies). Evaluate the effectiveness of current conservation programs/practices in managing the use of resources and the environment. Consider other practices that may be more effective in monitoring and managing the environment.

   When evaluating the effectiveness of current conservation programs, use strategies that are provided in Communications Skills, "Using Critical Thinking Skills".

2. Gather media reports on environmental issues that involve conflict or controversy. Issues investigated may relate to:

   - disposal of a toxic waste
   - contamination of ground waters.

   Through discussion and debate, encourage students to consider both sides of each issue before forming personal opinions and making decisions about appropriate action plans. Strategies that will assist students to examine environmental issues and choose appropriate courses of action are provided in The Role of Science and Technology in Society, "A Model for Decision-Making".

3. Discuss the value of "recycling" projects in making efficient use of energy resources. Identify materials suited to recycling (e.g., paper, glass, metal), as well as some possible uses of recycled products.

   Investigate the present use of recycling programs in the local community. If these programs do not exist, encourage students to:

   - formulate plans for a recycling project
   - explain how the project may conserve resources/energy
   - identify related entrepreneurial opportunities.

4. Student should recognize that although many of today's environmental problems have been caused by developments in science and technology, solutions to these problems are also provided through scientific research and technological development.

e.g., - disposal of radioactive wastes
- emission control systems for automobiles and industry
- scientific management of wildlife
- development of alternative sources of energy.

Encourage students to consider the relationship between science/technology and environmental quality by using ideas provided in The Role of Science and Technology in Society, "Interactions Among Science, Technology and Society"

THEME B

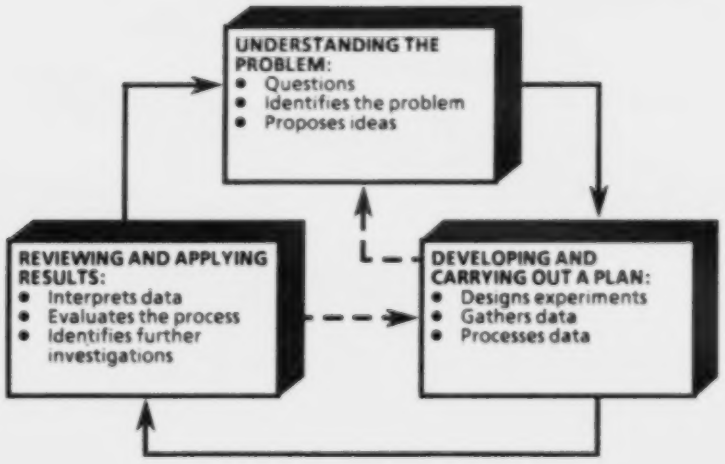
USING CHEMICAL PRODUCTS

Activities will focus attention on chemical substances and products that are frequently encountered by students in their everyday lives. By carrying out a series of controlled experiments, students will investigate the properties and reaction patterns of familiar chemical products used in their homes. Students will develop a strategy and respect for the safe handling of laboratory equipment and supplies, and should become aware of appropriate procedures for handling potentially dangerous materials that they may encounter in real life situations.

Teachers are encouraged to reference the "Generic Strategies" provided in this manual when planning for instruction. Strategies particularly relevant to the learning objectives and activities outlined in this theme can be found in:

- The Nature of Science
- Communication Skills
- Evaluation.

A MODEL FOR CONDUCTING SCIENTIFIC INQUIRY



CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

- Demonstrates an understanding of concepts previously developed in Grade 8:
  - recognizes properties of mixtures and solutions
  - identifies factors that affect solubility/speed of dissolving
  - distinguishes between dilute/concentrated/saturated solutions.
- Recognizes chemical and physical properties of familiar household substances.
- Identifies/distinguishes between chemical and physical change in household substances.
- Recognizes that chemical substances react according to predictable patterns.
- Demonstrates an understanding of acid and base substances used in the home:
  - natural properties of acids/bases
  - reactions of acids/bases with other household substances
  - their usefulness and potential dangers.
- Identifies factors that affect the reaction rates of chemical products used in the home:
  - temperature
  - concentration
  - surface area.
- Describes the nature of chemical changes that occur through oxidation:
  - burning
  - corrosion.
- Recognizes the usefulness, as well as the potential dangers, of chemical substances/reactions used in the home.
- Demonstrates understanding of safe procedures for handling and storing potentially dangerous chemical products.

SKILLS

- Measures mass/capacity/temperature/time using units, tools and procedures that are appropriate to the task performed.
- Uses inquiry skills to investigate chemical and physical properties/changes in household substances, demonstrating ability to:
  - manipulate materials
  - accurately observe/measure
  - identify and control variables
  - hypothesize and infer relationships
  - predict reactions.
- Identifies/classifies common household substances according to chemical composition.
- Follows appropriate procedures in monitoring:
  - acid/base reactions
  - oxidation reactions
  - factors that influence the reaction rate of chemical substances.
- Demonstrates an understanding of laboratory procedure in:
  - performing simple identification tests on household substances
  - working with acids and bases
  - comparing the solubility of given substances.

SKILLS (continued)

- Uses problem-solving skills in determining practical methods for inhibiting the corrosion of household materials:
  - identifies a problem related to corrosion
  - gathers related information/proposes possible alternatives
  - selects an alternative/builds a design
  - tests/evaluates/applies the design.
- Practises safe procedures for handling and storing laboratory/household materials that are potentially dangerous:
  - interprets hazardous product symbols
  - reads product ingredient labels
  - follows instructions for safe handling/storing
  - predicts the results/potential dangers of mixing certain products
  - identifies recovery techniques for errors in handling chemical substances.

ATTITUDES

- Displays a positive attitude toward self and the study of science:
  - assumes responsibility for personal conduct
  - performs investigations and completes assignments independently and in cooperation with others
  - practises strategies for resolving interpersonal conflict
  - shows interest and curiosity through willingness to ask questions/share observations and ideas/seek answers.
- Appreciates that all materials have a chemical composition of some kind.
- Realizes that science and technology have contributed to the development of a variety of chemical products that we depend upon and use each day.
- Realizes the usefulness of scientific inquiry skills in gathering information and explaining natural phenomena.
- Displays an attitude of personal safety, and concern for the safety of fellow students when handling hazardous equipment and supplies in the laboratory.
- Appreciates the potential dangers of hazardous chemical substances found at home and elsewhere in the community.

INTEGRATION ACTIVITIES

LANGUAGE ARTS

"Listening", "discussing', "reading" and "viewing" skills are used in gathering data and conducting scientific investigations. Students will "give" and "follow" directions when investigating the properties and reaction patterns of familiar chemical substances. Teachers are encouraged to discuss strategies for developing these skills with the language arts teacher.

MATHEMATICS

Students will use skills developed in mathematics class when they:

- measure mass/capacity/temperature/time
- interpret/classify/display data in table/chart/graph form
- interpret ratios that describe the composition/concentration of mixtures, solutions and other chemical substances.

Science teachers are encouraged to confer with the mathematics teacher in establishing appropriate strategies for reinforcing mathematical concepts/skills. Plan activities that will enable students to:

- use mathematics class to interpret and display the data they gather through experiments performed in science class
- use science class to make mixtures and solutions the composition and concentration of which correspond to ratios studied in mathematics class.

SOCIAL STUDIES

Through current affairs, students will develop an awareness of potential problems related to the use of chemical substances and products in the local community:

- personal safety hazards
- disposal problems
- environmental concerns.

Social studies students might use comparative mapping activities to consider the pros and cons of using familiar chemical products that are potentially hazardous to personal health or the environment.

PRACTICAL ARTS

Chemical substances are frequently used in the workplace. Within the practical arts program, students are given opportunities to develop appropriate strategies for handling, storing and disposing of chemical products used in work-related situations.

Conferencing among science and practical arts teachers will assist in identifying chemical substances/products that are used by students in the practical arts program. Opportunity might then be provided for students to investigate the properties and reaction patterns of these substances in science class. Chemical products investigated by students may include:

- cleaning fluids
- lubricating fluids
- cooking/baking ingredients
- beverages
- paints
- child care products.

COMMUNITY PARTNERSHIP OPPORTUNITIES

- Invite a paramedic/fire chief to discuss:
  - the hazards and safe handling/storage techniques for potentially dangerous products found in the home/workplace
  - methods of minimizing the occurrence of fires in the home/workplace
  - appropriate methods of extinguishing different types of fires.

- Invite a local pharmacist to discuss the chemical properties/active ingredients of mixtures and solutions used in personal care products.

- Invite a representative from the baking, hair care, dry cleaning or automotives industry to discuss the chemical properties/active ingredients of mixtures and solutions used in their respective service areas. Discuss the potential danger of mixing certain kinds of chemical substances.

- Visit local industries and observe:
  - the use of chemical products and processes
  - safe handling techniques followed by workers.

- Invite a local agriculturalist/soil expert to discuss the effects of soil acidity on plant growth, and methods of adjusting acid level in soil.

- Invite a local doctor/health nurse to discuss:
  - the potential dangers of making skin contact with, or ingesting, certain household chemicals
  - recovery techniques for errors in handling certain household chemicals
  - the function of chemical substances/reactions that occur naturally inside the human body (e.g., digestion, respiration).

- Invite an environmentalist to speak to the class about environmental problems that are caused by the reaction patterns of certain kinds of chemical substances:
  - contaminated ground/surface waters
  - acid rain
  - smog
  - oil slicks.

- Visit local stores in an attempt to gather information provided on the labels of familiar household products (e.g., hazardous chemical symbols, product ingredients, directions for use, recovery techniques for errors in handling).

BASIC RESOURCE CORRELATION

Science Plus Technology and Society 9
- Unit: Chemical Changes

SUGGESTED ACTIVITIES

Science Plus Technology and Society 9 and its corresponding *Teacher Resource Book* provide a variety of activity-based investigations that support the learning objectives identified in this theme. The activities that follow may be used to supplement those provided in the basic learning resource. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

Demonstrates an understanding of concepts previously developed in Grade 8:
- **recognizes properties of mixtures and solutions**
- **identifies factors that affect solubility/speed of dissolving**
- **distinguishes between dilute/concentrated/saturated solutions.**

1. Prepare a wall chart/bulletin board display that outlines and summarizes:

   - properties of mixtures and solutions
   - factors that affect solubility/speed of dissolving
   - distinguishing features among dilute, concentrated and saturated solutions.

   Encourage students to gather samples (or collect pictures) of familiar chemical products that illustrate related concepts (e.g., cooking and baking ingredients, household cleaning products). Ask students to distinguish between products that are solutions and non-solutions, and to classify solutions as dilute, concentrated or saturated.

2. Use appropriate questioning techniques to identify problems and formulate hypotheses that relate to:

   - methods of separating partners of a mixture
   - factors affecting the solubility of substances
   - the effect of a solute on the freezing/soiling point of a liquid.

   Provide opportunities for students to plan and conduct investigations that may verify the hypotheses they make. Assist students to identify and control variables in their investigations, thus increasing the reliability of the results they obtain.

   Strategies that may assist students to plan and conduct scientific investigations are provided in The Nature of Science, "Strategies for Developing the Inquiry Skills".

3. Demonstrate and model appropriate safety procedures for working with apparatus and supplies in the science laboratory. Emphasize a common sense approach to accident prevention. Ask students to prepare posters/cartoons/slide sets/videotapes that illustrate the safe laboratory procedures they are using.

LEARNING OBJECTIVE

Recognizes chemical and physical properties of familiar household substances.

1. Ask students to observe and describe the physical and chemical properties of familiar household substances used in the kitchen, laundry room and workshop.
   e.g., Physical Properties – how a substance looks/feels/tastes/smells, and physical changes the substance may undergo (e.g., melting, freezing, boiling, breaking)

   Chemical Properties – chemical changes/reactions that the substance may undergo, or chemical changes/reactions that will not occur (e.g., burning, rotting, rusting, digesting)

   Attribute guides are useful in establishing a structure for observing familiar chemical substances. A sample attribute guide is provided in The Nature of Science, "Gathering Data". Teachers may wish to modify this guide by selecting attributes that are appropriate to the chemical substances being examined.

2. Perform the experiment described in Resource 1: Chemical and Physical Properties. The activities outlined in this experiment provide additional opportunities for students to investigate the chemical and physical properties of different substances.

   Strategies that will assist students to use inquiry skills appropriate to this investigation are provided in The Nature of Science, "Strategies for Developing the Inquiry Skills".

3. Place students in small groups to play "Name the Product". Instructions for play are outlined below.

   a. Ask one member of each group to provide clues as to the identity of a particular household substance by describing its chemical and physical properties.
   b. Other members of the group should attempt to identify the substance on the basis of the clues provided (i.e., the chemical and physical properties of the substance).
   c. The first student to identify correctly the substance, then provides clues as to the identity of another household substance by describing its chemical and physical properties.

LEARNING OBJECTIVE

Identifies/distinguishes between chemical and physical change in household substances.

1. Compare and contrast chemical changes with physical changes. Assist students to distinguish between these two kinds of changes by formulating a list of key words that can be used to describe "chemical changes" and another list of key words that describe "physical changes".

e.g.,

Chemical Change	Physical Change
burning	evaporating
rusting	freezing
rotting	drying
fizzing	dissolving
bubbling	splitting

Questions that may assist in distinguishing between chemical and physical change include:

- Was there a change in colour?
- Was heat or light given off?
- Can the change be easily reversed?
- Was the substance destroyed?
- Was a new substance formed?
- Were any bubbles formed?
- Was a new odour produced?

2. Ask students to list, in chart form, a variety of chemical and physical changes that occur in the kitchen. Classify each change as chemical or physical, and provide reasons for classifying the change in this way.

CLARIFICATION/EXAMPLE

CHANGE	PHYSICAL	CHEMICAL	REASONS
melting ice cubes	✓		– change is easily reversed

LEARNING OBJECTIVE

Recognizes that chemical substances react according to predictable patterns.

1. Ask students, individually or in small groups, to observe and describe what happens when:

- a candle burns
- 5 mL of vinegar are added to 2 grams of baking soda
- 5 grams of salt are added to 25 mL of water at room temperature
- a single crystal of potassium permanganate is placed in a beaker containing 100 mL of water
- kernels of popping corn are placed in a beaker containing water and an alka seltzer tablet.

Provide opportunities for students to compare the results of their investigations with other members of the class. Students should recognize that similarities among observations illustrate predictability of the properties and reaction patterns of chemical substances.

Activities that may help students to observe and describe chemical reactions are provided in The Nature of Science, "Resource 3: Observing and Describing" and "Resource 4: An Evaluation Guide for Observations".

2. Discuss the following statement:

> "Chemical changes can be used to identify substances because chemical substances react according to predictable patterns".

Illustrate the significance of this statement by demonstrating several simple chemical tests (e.g., the tests for starch, carbon dioxide, limestone).

LEARNING OBJECTIVE

Demonstrates an understanding of acid and base substances used in the home:
- **natural properties of acids/bases**
- **reactions of acid/bases with other household substances**
- **their usefulness and potential dangers.**

1. Identify a variety of familiar acids and bases found in the home.

e.g.,	Acids	Bases
	citric acid	milk of magnesia
	milk	lye
	vinegar	ammonia
	aspirin	baking soda

Develop techniques for distinguishing between acids and bases by observing the natural properties of these substances:

- acids taste sour, bases taste bitter
- acids wear away metals and cause colour changes
- bases feel slippery/soapy and dissolve fats and oils
- bases destroy the properties of an acid.

2. Investigate the acid/base reactions that occur in a variety of household situations:

- sour milk and its effect on baking soda in producing baked goods
- the use of lemon juice to dispel fish odours
- the removal of stains with vinegar
- hair shampoo and rinse
- antacids for the stomach
- oven and drain cleaners
- the actions of soaps and detergents.

3. Provide opportunities for students to test common household substances for their acidic/basic properties by conducting the investigations outlined in:

- Resource 2: Acids and Bases
- Resource 3: The Blue and Red Cabbage

A variety of strategies that will assist students to develop and use inquiry skills that are appropriate to these investigations are provided in The Nature of Science, "Strategies for Developing the Inquiry Skills".

4. Identify acids present in the human body and discuss their role in the digestive process.

   Design and conduct an investigation that will determine the effect of a "brand name" antacid on a dilute solution of hydrochloric acid. Generalize the results of this investigation to explain the use of antacids in neutralizing excess acidity in the digestive system.

5. Investigate methods of testing for soil acidity (i.e., pH level).

   Assist students to design and conduct experiments that test the effect of acid levels in soil on the growth of plants. When designing experiments, maintain experimental control by varying soil acidity and keeping other factors that affect plant growth constant.

   Identify practical methods of controlling acid levels in soil:

   - liming
   - addition of humus.

6. Discuss the importance of accurately identifying acid and base substances used in the household. Examine the warning labels on a variety of household products. Discuss the potential dangers of mixing:

   - bleach and drain cleaners
   - ammonia and bleach
   - ammonia and aluminum.

LEARNING OBJECTIVE

Identifies factors that affect the reaction rates of chemical products used in the home:
- **temperature**
- **concentration**
- **surface area.**

1. Investigate the effects of temperature on the rusting process by performing the experiment outlined below.

   a. Place equal amounts of moistened steel wool in three sealed glass jars. Label the jars A, B and C.
   b. Place jar A in a refrigerator/cooler, jar B on a heat vent, and jar C on a table in the classroom at room temperature.
   c. Observe and record the changes that take place in each jar over a period of several days. Discuss differences in the chemical reactions that occur within each of the jars.

2. Provide opportunities for students to compare the effects of temperature change on the solubility of different substances. Perform the experiment outlined in Resource 4: The Effects of Temperature on Solubility.

   Students may wish to construct a "solubility curve" that illustrates the results of this investigation.

3. Demonstrate how temperature, concentration and surface area affect the reaction rate of an antacid tablet:

   a. Obtain five 250 mL beakers. Label them A, B, C, D and E.

b. Fill beaker A with 125 mL of hot water, and beaker B with 125 mL of cold water. Place an antacid tablet in each beaker. Observe and record the reaction rate in each beaker.
c. Fill beaker C and beaker D each with 125 mL of eater at room temperature. Place a whole antacid tablet in beaker C and a crushed antacid tablet in beaker D. Observe and record the reaction rate in each beaker.
d. Fill beaker E with 125 mL of water at room temperature. Place an antacid tablet in beaker E and record the reaction rate. When the tablet has dissolved, add a second antacid tablet to beaker E. Record the time it takes for the second tablet to dissolve.
e. Discuss and compare the reactions observed in beakers A. B, C, D and E.

4. Debate the following statement:

"Identifying the factors that affect reaction rates, science and technology enables us to control chemical reactions. Many chemical products and reactions used in the home have therefore become safer and more efficient."

Structure discussion and debate using strategies provided in Communication Skills, "Strategies for Discussing and Debating".

LEARNING OBJECTIVE

Describes the nature of chemical changes that occur through oxidation:
- **burning**
- **corrosion.**

1. Investigate chemical changes that occur through oxidation by performing the following demonstration:

a. Obtain five clean nails and five test tubes. Label the test tubes A, B, C, D and E.
b. Half-fill test tube A with vinegar, test tube B with distilled water, and test tubes C, D and E respectively with dilute solutions of sodium hydroxide, potassium chromate and hydrochloric acid.
c. Place a nail in each test tube. After one or two days, observe each test tube for evidence of corrosion.
d. Discuss and compare the results in each test tube.

2. Discuss instances of slow oxidation in the natural environment.

e.g., – respiration
– rusting and corrosion
– spontaneous combustion
– food decay.

Identify procedures that can be used to control the negative effects of slow oxidation:

- inhibiting rust/corrosion by coating materials with paint or a lubricant
- reducing the risk of spontaneous combustion by providing adequate ventilation
- reducing food decay through refrigeration and the use of air-tight packaging.

3. Changes in <u>colour</u>, <u>odour</u> and <u>weight</u> often accompany a chemical change. Illustrate how these attributes change when a substance undergoes the chemical process of "burning".

a. Record the mass, colour and odour of a piece of filter paper.
b. Burn the filter paper and collect the ashes.
c. Record the mass, colour and odour of the ashes.
d. Identify changes in mass, colour and odour that have occurred through the "burning" process.

4. Encourage students to recognize elements of the fire triangle (e.g., fuel, oxygen, heat), and to apply knowledge of these elements in identifying appropriate methods of controlling combustion.

   Invite a fire chief/paramedic to discuss appropriate methods for controlling different types of fires.

5. Develop and reinforce vocabulary related to chemical products and reactions. Vocabulary development activities are provided in Communication Skills, "Developing Technical Vocabulary".

LEARNING OBJECTIVE

Recognizes the usefulness, as well as the potential dangers, of chemical substances/reactions used in the home.

1. Through brainstorming, identify a variety of chemical substances/reactions present in the home. Consider the usefulness and potential dangers of these substances/reactions by completing a chart similar to the one illustrated below.

SUBSTANCE/ REACTION	LOCATION IN THE HOME	FUNCTION/USE	POTENTIAL DANGER

2. Collect samples of a variety of chemical substances found in the home. Test the pH level of each substance. Classify the substances as acid, base or salt according to the results of chemical tests that have been performed. Discuss hazards associated with mixing acid and base materials.

3. Invite a pharmacist/paramedic to describe the chemical properties and active ingredients of familiar household products. Emphasize both the usefulness of these products, as well as potential dangers that accompany their use.

LEARNING OBJECTIVE

Demonstrates understanding of safe procedures for handling and storing potentially dangerous chemical products.

1. Prepare a display of "product labels" found on a variety of chemical substances used in the home (e.g., soaps, detergents, cleaning fluids, personal hygiene products, cooking and baking ingredients). The display should include:

   - the brand name of each product
   - the chemical name of each product
   - safe procedures for using/storing each product
   - recovery techniques for errors in handling

2. Contact the "Poison Control Centre" in your area for information concerning:

   - safe handling procedures for chemical products frequently used in the home
   - emergency treatment/recovery techniques for errors in handling household chemicals.

3. Through brainstorming, formulate a list of "do's" and "don'ts" for handling/storing chemical products in the home.

   Simulate a variety of situations in the home that involve the use of potentially dangerous chemical products. Ask students to describe appropriate procedures/actions in each situation.

   Invite a pharmacist/paramedic/doctor to class. Ask this person to:

   - evaluate the safety procedures/strategies formulated by students
   - suggest other procedures/strategies that might be used in these situations.

RESOURCE 1: CHEMICAL AND PHYSICAL PROPERTIES

OBJECT To discover chemical and physical properties of various substances

APPARATUS
magnifying glass
hot plate
spring-type pin

SUPPLIES

popsicle sticks	5 mL salt
toothpicks	5 mL sugar
vinegar	5 mL baking soda
water	5 mL starch
tincture of iodine	5 mL plaster of Paris
aluminum foil	

PROCEDURE

1. In your notebook, draw a table like the one illustrated on the next page. Use the table to record your observations.
2. Examine each sample of powder with a magnifying glass. Describe the appearance of each powder.
3. Feel each powder by rubbing it between two fingers. Describe how each powder felt.
4. Smell each powder. Describe the odour of each powder.
5. Make five little cups by shaping round pieces of aluminum foil (about 5 cm in diameter). Using masking tape, label the cups for each of the five powders.
6. Use a popsicle stick to scoop a small amount of each powder into its cup.
7. Add three or four drops of water to each cup and stir, using a different toothpick for each cup. Record your observations for each substance.
8. Repeat steps 6 and 7 using fresh powders. This time, however, add three or four drops of vinegar to each cup instead of water. Record your observations for each substance.
9. Repeat steps 6 and 7 again. This time, add three or four drops of dilute tincture of iodine to each cup (e.g., 2 mL of iodine in 100 mL of water). Record your observations for each substance.
10. Heat a small amount of each substance in a foil dish by holding it with a clothespin over a hot plate. Record your observations for each substance.

OBSERVATIONS

TEST	SUGAR	SALT	BAKING SODA	STARCH	PLASTER OF PARIS
Appearance					
Texture					
Smell					
Reaction with water					
Reaction with vinegar					
Reaction with iodine					
Reaction to heat					

CONCLUSIONS

1. Would you be able to identify the five powders used in this investigation by their appearance alone?

_____

_____

2. Would feeling the powders help you to identify them?

_____

_____

3. Would the odour of each powder be of any help in its identification?

_____

_____

_____

CONCLUSIONS (continued)

4. Which powder can you positively identify by its reaction with water? Why?

5. Which powder can you positively identify by its reaction with vinegar? Why?

6. Which powder can you positively identify by its reaction with iodine? Why?

7. Which powder changed the most when it was heated? How did it change?

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RESOURCE 2: ACIDS AND BASES

OBJECT To test common kitchen substances for acid or base properties.

APPARATUS
5 – 25 mL beakers
5 eyedroppers
watch glass
safety goggles

SUPPLIES

25 mL vinegar	3 g cream of tartar
25 mL ammonia	3 g baking soda
25 mL distilled water	4 strips red litmus paper
25 mL sour milk	4 strips blue litmus paper
25 mL citrus fruit juice	2 drinking straws or wooden splints

PROCEDURE

A. Place a drop of vinegar on one end of a strip of red litmus paper and a strip of blue litmus paper.

B. Using the same two strips of litmus paper, place a drop of ammonia water on the other end of each.

C. Place a drop of distilled water on a new strip of red litmus paper and on a new strip of blue litmus paper.

D. Wet one new strip of red litmus paper and one new strip of blue litmus paper by placing several drops of distilled water on each.

Using a straw as a scoop, place a small amount of cream of tartar on one end of each of these strips of litmus paper.

Using the other straw as a scoop, place a small amount of baking soda on the other end of each strip of litmus paper.

E. Using an eyedropper, place a drop of sour milk and a drop of citrus fruit juice on a new strip of red litmus paper and on a new strip of blue litmus paper.

F. With the straws used in Step D, place a small amount of cream of tartar and a small amount of baking soda in a watch glass.

Mix the two powders well. Then add one or two drops of distilled water.

RESOURCE 2: ACIDS AND BASES (continued)

OBSERVATIONS

Record your observations in Steps A to F using the chart provided below.

SUBSTANCE	RED LITMUS PAPER	BLUE LITMUS PAPER
vinegar		
ammonia		
distilled water		
cream of tartar		
baking soda		
sour milk		
citrus fruit juice		

CONCLUSIONS

1. What is the effect of acidic substances on red litmus paper? On blue litmus paper?

_____

_____

_____

2. What is the effect of basic substances on red litmus paper? On blue litmus paper?

_____

_____

_____

3. Identify the following substances as being acid, base or neither by placing a check mark on the appropriate line.

	Acid	Base	Neither
a. vinegar	_____	_____	_____
b. ammonia	_____	_____	_____
c. distilled water	_____	_____	_____
d. cream of tartar	_____	_____	_____
e. baking soda	_____	_____	_____
f. sour milk	_____	_____	_____
g. citrus fruit juice	_____	_____	_____

4. Explain what happened to the powders (i.e., cream of tartar and baking soda) in Step F when you added distilled water? Why did this happen?

_____

_____

_____

5. Predict what might happen if you added vinegar to baking soda. Verify your prediction through experimentation.

_____

_____

_____

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RESOURCE 3: THE BLUE AND RED CABBAGE

OBJECT To develop and use a homemade acid/base indicator.

APPARATUS
a small beaker
4 test tubes
test tube rack
hot plate
retort stand

SUPPLIES
several leaves of cabbage
vinegar
lemon juice
baking soda
lime

PROCEDURE

1. Cut a red cabbage leaf into small pieces. Place the pieces of red cabbage in a beaker. Add 10 mL of water to the beaker.

2. Heat the cabbage and water mixture until the water boils. Pour equal amounts of the liquid into four test tubes.

3. Place a few drops of vinegar in the first test tube, and a few drops of lemon juice in the second test tube. Carefully observe the colour of the liquid in each test tube.

4. Add a pinch of baking soda to the third test tube, and a pinch of lime to the fourth test tube. Observe the colour change in each test tube.

OBSERVATION

Record your observations in steps 3 and 4, using the chart provided below.

SUBSTANCE	COLOUR OF CABBAGE WATER
vinegar	
lemon juice	
baking soda	
lime	

RESOURCE 3: THE BLUE AND RED CABBAGE (continued)

CONCLUSIONS

1. Which substances coloured the cabbage water red?

2. Which substances coloured the cabbage water blue?

3. To which of the two groups of substances (e.g., acidic, basic) would orange juice belong? Pineapple juice? Grape juice? Soapy water?

4. Predict what might happen if we added vinegar to the blue liquid. Verify your prediction through experimentation.

Note to teacher:

The cabbage water acts like litmus paper. It turns red in acids and blue in bases. Vinegar, lemon juice and other sour-tasting juices are all acids. Baking soda, lime and soapy water are bases. Chemists describe acidic and basic substances in terms of their pH level. A pH level of 7 represents a neutral substance. Acids have pH levels that are less than 7, and bases have pH levels that are higher than 7 (up to 12).

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RESOURCE 4: THE EFFECTS OF TEMPERATURE ON SOLUBILITY

OBJECT To compare the effects of temperature change on the solubility of different salts.

APPARATUS
three 250 mL beakers
stir rods
scoop
hot plate
retort stand

SUPPLIES
potassium nitrate
sodium chloride
calcium acetate

PROCEDURE

1. Using the three beakers, prepare saturated solutions of potassium nitrate, sodium chloride and calcium acetate at room temperature. When making the saturated solutions, add half a teaspoon of salt at a time to 100 mL of water, until some solid is left undissolved after stirring for one minute.

2. Heat Beaker 1 (containing potassium nitrate). As soon as the solid particles dissolve, add additional salt, half a teaspoon at a time, until some solid remains undissolved.

3. Repeat step 2 with Beater 2 (containing sodium chloride).

4. Repeat step 2 with Beaker 3 (containing calcium acetate).

OBSERVATION

Describe and compare your observations of the reactions that occurred in Beakers 1, 2 and 3.

Beaker 1: _____

_____

Beaker 2: _____

_____

Beaker 3: _____

_____

RESOURCE 4: THE EFFECTS OF TEMPERATURE ON SOLUBILITY (continued)

CONCLUSIONS

1. Most salts behave like those in Beaker 1 and Beaker 2. What affect does increasing temperature have on the solubility of the salts in Beaker 1 and Beaker 2?

_____

_____

_____

2. What must be done in order to dissolve more calcium acetate in Beaker 3?

_____

_____

_____

3. Describe what happened to the three salt solutions after they cooled to room temperature.

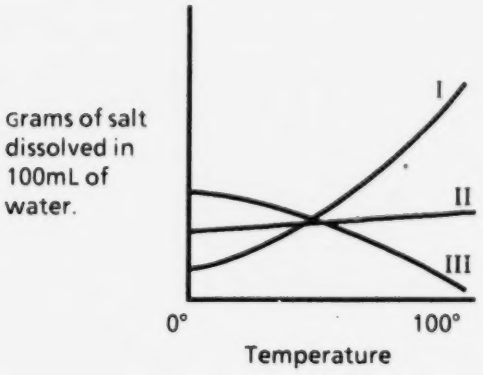
_____

_____

_____

Note to teacher:

The solubility of a substance generally increases as temperatures rise (see solubility curves I and II below). Solubility curve III (which describes the reaction in Beaker 3) is very seldom encountered.



When conducting this investigation, ask students to monitor and record the amount of salt added to the water and the temperature of the solution. Then plot a "solubility curve" similar to the one illustrated above, which summarizes the information gathered.

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THEME C

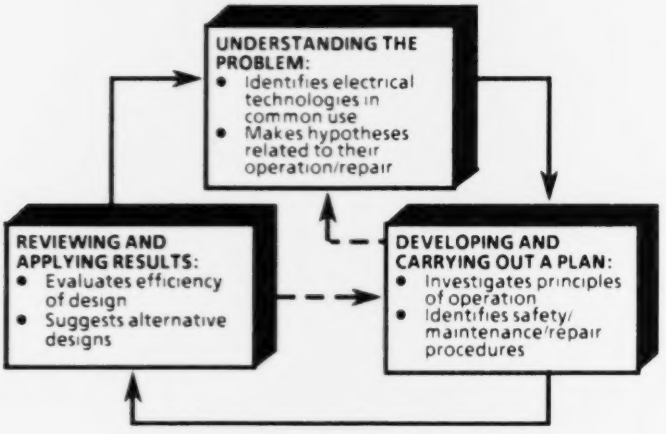
ELECTRICAL SYSTEMS IN THE HOME

Interrelated forms of magnetism, electricity and energy are used each day in a variety of household technologies. Investigation will focus attention on the basic principles of magnetic energy, how it is related to electrical energy, and the many technological applications made of electromagnetism. Students will become aware of the inherent hazards of electricity, as well as gain experience in the actual construction and repair of simple electrical systems. Activities that demonstrate our dependence on energy systems and the need to manage our use of electrical energy will enable students to become increasingly "energy wise".

Teachers are encouraged to reference the "Generic Strategies" provided in this manual when planning for instruction. Strategies particularly relevant to the learning objectives and activities outlined in this theme can be found in:

- The Relationship Between Science and Technology
- Communication Skills
- Evaluation.

A MODEL FOR SOLVING TECHNOLOGICAL PROBLEMS


UNDERSTANDING THE PROBLEM:
• Identifies electrical technologies in common use
• Makes hypotheses related to their operation/repair
DEVELOPING AND CARRYING OUT A PLAN:
• Investigates principles of operation
• Identifies safety/ maintenance/repair procedures
REVIEWING AND APPLYING RESULTS:
• Evaluates efficiency of design
• Suggests alternative designs

CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

- Demonstrates an understanding of the basic principles of:
  - static electricity
  - magnetism.
- Describes the interrelationship between magnetism and an electric current.
- Gives examples of electrical circuits, identifying:
  - the source of electricity
  - the conducting path
  - energy users along the path.
- Recognizes methods of producing electrical energy for home consumption:
  - chemical action
  - generators.
- Describes basic principles of electrical resistance, and gives examples of their application in:
  - selecting appropriate conductors
  - electrical technologies designed to produce light and heat.
- Demonstrates, through sketches/assembly/construction, an understanding of basic household circuitry:
  - series and parallel circuits
  - conductors and insulators
  - switches
  - short circuits
  - safety features (e.g., grounding devices, fuses/circuit breakers).
- Relates principles of magnetism and electricity to the operation of familiar electrical technologies (e.g., doorbell, electric motor, electric toys/games, kitchen appliances, hair dryer).
- Illustrates energy flow and transformation in familiar electrical technologies.
- Recognizes hazards inherent in the use of electricity:
  - identifies potentially dangerous situations
  - predicts possible consequences of unsafe habits/routines.
- Monitors personal consumption of electrical energy in the home, recognizing strategies that will ensure its efficient use.

SKILLS

- Measures electrical current, using appropriate units/tools/procedures.
- Performs experiments with static electricity/magnetism/simple electrical circuits, demonstrating ability to:
  - manipulate materials
  - follow appropriate safety precautions
  - make accurate observations
  - collect and record data
  - interpret data/draw conclusions.
- Demonstrates an understanding of appropriate laboratory procedures in:
  - assembling series and parallel circuits
  - constructing a simple electromagnetic system
  - repairing a short-circuit.

SKILLS (continued)

- Interprets/draws simple diagrams of electrical circuits.
- Analyzes familiar electromagnetic devices, identifying:
  - subsystems
  - component parts
  - energy flow/transformation.
- Applies problem-solving skills in troubleshooting electrical devices/systems containing relatively few components:
  - identifies the source of the problem
  - considers alternative approaches to a solution
  - evaluates alternatives and makes necessary repairs.
- Constructs/invents a simple electrical device intended to perform a given function.
- Performs simple calculations related to personal consumption of electrical energy, determining:
  - energy used in performing specific household tasks
  - energy costs related to the tasks performed.

ATTITUDES

- Displays a positive attitude toward self and the study of science:
  - assumes responsibility for personal conduct
  - performs investigations and completes assignments independently and in cooperation with others
  - practises strategies for resolving interpersonal conflict
  - shows interest and curiosity through willingness to ask questions/share observations and ideas/seek answers.
- Appreciates the usefulness of technological problem-solving skills in finding solutions to practical problems.
- Demonstrates confidence in personal ability to solve practical problems.
- Realizes the relationship between science and the development of familiar electrical technologies.
- Appreciates the extent to which science and electrical technology have influenced and changed society.
- Develops an attitude of safety toward the use of electrical devices.
- Displays responsible attitudes toward energy consumption as it relates to personal and global needs.

INTEGRATION ACTIVITIES

LANGUAGE ARTS

Students will use a variety of communication skills throughout activities in this theme. Instructional activities will require students to:

- give and follow directions when planning and performing investigations
- use comprehension skills when processing and analyzing data obtained through investigation/experimentation
- use critical/creative thinking skills when inventing and constructing a simple electrical device.

Teachers are encouraged to identify appropriate strategies for developing these skills through cooperative conferencing with teachers of language arts. Strategies for developing communication skills frequently used in science are also provided in the "Communication Skills" section of this manual. Learning activities intended to develop an understanding of the relationship between science and technology may involve research and writing activities that can be integrated with the language arts program.

MATHEMATICS

Students will use a variety of mathematical skills in gathering and interpreting data. Mathematical skills may include:

- the use of tables/charts/graphs in analyzing and communicating the results of investigation
- writing/manipulating ratios and proportions when monitoring electrical consumption/costs
- interpreting algebraic sentences (formulas) that describe scientific phenomena.

Cooperative planning will provide opportunities for students to apply mathematical skills that have been learned in scientific contexts. Scientific data and relationships studied in science class might be organized/analyzed through the use of numbers and algebraic symbols in mathematics class.

SOCIAL STUDIES

Students will develop an awareness of current energy issues through activities in current affairs. Cooperative planning between the science and social studies teachers might provide opportunities for students to investigate a current energy concern, its impact on our province/country, and possible alternatives/solutions to the issue.

The social studies program will also provide opportunities for students to:

- recognize the impact of electrical technologies upon the social/economic structure of Alberta/Canada
- recognize changes in job trends caused by the development of labour saving devices.

PRACTICAL ARTS

Thematic concepts/skills can be reinforced throughout the practical arts program. Provide opportunities for students to analyze the electrical technologies they use within the practical arts program by:

- identifying the scientific principles that govern their operation
- developing appropriate strategies for using/maintaining/repairing these technologies.

Encourage students to recognize occupational/entrepreneurial opportunities that are related to maintenance and repair of electrical technologies.

COMMUNITY PARTNERSHIP OPPORTUNITIES

- Visit local business/industry (e g , service station, restaurant, appliance repair shop) for first-hand observation of electrical technologies in use. Make a list of electrical technologies that are used. Identify the scientific principles that govern the operation of these technologies.

- Visit a local power generating plant. Make note of the energy transformations and technologies being used.

- Invite an electrician/electronics repair person to discuss:
  - basic principles and applications of electrical circuitry
  - the need for regular maintenance and repair of electrical technologies
  - hazards inherent in the use of electricity and related safety practices.

- Invite a representative from the local electrical utility company to discuss strategies for monitoring and conserving electrical energy consumption in the home.
  e.g., - How do you read an electric meter?
  - Why do some appliances use more energy than others?
  - What are the energy costs related to performing specific household tasks?

- Visit a residential construction site and note electrical circuits that have been installed prior to the drywall stage. If possible, have students examine technical drawings for the electrical system within a home.

- Invite a doctor/nurse to discuss hazards inherent in the use of electricity, and to identify related safety practices/emergency treatments for electrical shock.

- Invite an engineer/environmentalist to discuss issues that relate to the supply and use of electrical energy in the local area.

- Arrange visits/interviews with scientists and engineers. Distinguish between the nature of the work performed by scientists and engineers. Discuss the contributions made by Canadian scientists and engineers to the fields of science and technology (e g , the arm for the NASA space shuttle).

- Interview several senior citizens. Ask them to describe ways in which society has changed over the last 30-50 years as a result of developments in electrical technology.

BASIC RESOURCE CORRELATION

Science Plus Technology and Society 9
- Unit: Electromagnetic Systems

SUGGESTED ACTIVITIES

Science Plus Technology and Society 9 and its corresponding *Teacher Resource Book* provide a variety of activity-based investigations that support the learning objectives identified in this theme. The activities that follow may be used to supplement those provided in the basic learning resource. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

Demonstrates an understanding of the basic principles of:
- **static electricity**
- **magnetism.**

1. Encourage students to describe first-hand experiences they have encountered with static electricity. These experiences may involve:

   - the forces that attract tiny pieces of paper to a comb after a comb has been run through the hair
   - the forces that attract lint to a woolen jacket or pair of slacks
   - what happens when you rub your feet while walking on a carpet and then touch someone
   - a bolt of lightning during a thunderstorm.

   Through brainstorming, make a list of:

   - some applications of static electricity in everyday life
   - ways in which static electricity is a nuisance.

2. Provide opportunities for students to investigate:

   - how charges of static electricity are produced
   - the laws of repulsion and attraction in static electricity.

   Students may wish to place electrical charges on a variety of familiar objects, and use an electroscope to observe the behaviour of objects with like/unlike electrical charges.

3. Illustrate the magnetic field which surrounds a magnet by:

   - placing a magnet on an overhead projector
   - covering the magnet with a piece of glass
   - sprinkling iron filings around the magnet.

   The laws of magnetism can also be illustrated by:

   - placing the like/unlike poles of two magnets a short distance apart on an overhead projector
   - covering the magnets with a piece of glass
   - sprinkling iron filings around the like/unlike poles of the two magnets.

Ask students to draw diagrams that illustrate the lines of magnetic force between like/unlike poles of a magnet.

4. Create a display centre of "magnetic" and "non-magnetic" materials. Identify criteria that might be used to classify familiar materials as magnetic or non-magnetic.

LEARNING OBJECTIVE

Describes the interrelationship between magnetism and an electric current.

1. Provide opportunities for students to observe and describe the magnetic effects of an electric current flowing through a wire:

   - place a compass in various positions around a wire carrying an electric current. Note the magnetic effects of the electric current on the compass needle
   - construct an electromagnet. Relate variables in construction (e.g., number of turns of wire, number of dry cells, type of core) to the strength of the electromagnet.

2. Investigate the application of electromagnetics in familiar technologies (e.g., electric motor, door bell, telephone, tape recorder). Ask students to:

   - construct a simple technological device that involves application of the electromagnet
   - disassemble old/non-functional electrical devices that use electromagnets.

   Strategies that will assist students in recognizing how electromagnetic principles are used in the development of familiar technologies are provided in The Relationship Between Science and Technology, "Understanding Science and Technology".

3. Demonstrate the relationship between magnetism and electricity by moving a magnet through a conducting coil. Use a galvanometer to detect the electric current that is produced in the conducting coil.

   Further investigate the role of magnets in producing electricity by asking students to:

   - disassemble an old/non-functional electric generator
   - construct a model of a simple electric generator.

4. Research discoveries made about the relationship between magnetism and electricity by the British physicist Michael Faraday.

   Structure research activities using strategies provided in Communication Skills, "Reading and Viewing Science Materials" and "Summarizing, Evaluating and Communicating Ideas in Science".

LEARNING OBJECTIVE

Gives examples of electrical circuits, identifying:
- **the source of electricity**
- **the conducting path**
- **energy users along the path.**

1. Ask students to identify simple electric circuits used around the home. These circuits may be found in:

   - a battery operated toy
   - an old/non-functional electrical appliance.

Further investigate each circuit through disassembly. Encourage students to describe the function of component parts within each circuit.

2. Provide opportunities for students to:

   - follow a simple circuit diagram in constructing an electric circuit
   - prepare a circuit diagram for a simple electric circuit they have constructed.

   Ask students to interpret each circuit by identifying its source of electricity, the conducting path, and energy users along the path.

3. Investigate the distribution of electrical energy:

   - from the electrical generating plant to the home
   - throughout electrical circuits within the home.

   Invite an electrician or representative from the local electrical utility company to discuss the circuitry used in distributing electrical energy throughout the home and community. Prepare a wall chart/bulletin board display that summarizes the results of this investigation.

   Have students analyze and draw simple circuit diagrams for a portion of the electrical system in their home.

LEARNING OBJECTIVE

Recognizes methods of producing electrical energy for home consumption:
- **chemical action**
- **generators.**

1. Demonstrate how an electric current can be produced through chemical action in a wet cell.

   e.g., Insert zinc and copper strips in a lemon. Connect the zinc and copper strips to a galvanometer (or a 0.2 volt bulb) by using a good conductor. Note the electric current produced by the chemical reaction between the lemon and zinc/copper strips.

   Investigate other types of wet cells that can be used to produce an electric current. Discuss applications of the wet cell in producing electrical energy (e.g., car battery).

2. Investigate the use of dry cells in producing electrical energy by chemical action:

   a. Obtain a dry cell. Carefully cut it open.
   b. Identify the function of component parts of the dry cell.
   c. Draw a diagram of the dry cell.
   d. Write a brief description of how electrical energy is produced in the dry cell.

3. Invite an electrician (or knowledgeable salesperson from the local hardware store) to demonstrate and explain:

   - why dry cells lose their energy
   - how rechargeable batteries work.

   Students may wish to compare the voltage readings of different types/sizes of dry cells, and determine if:

   - large batteries produce greater voltages than small batteries
   - old batteries produce less energy than new batteries
   - certain "brand name" batteries produce more energy/last longer than others.

4. Research how the generator produces electrical energy for the local community. Research activities may include:

   - investigating scientific principles that govern the operation of the generator (e.g., an electric current is produced in a conducting coil when the coil moves through a magnetic field)
   - visiting the local power generating plant for first-hand observation of the generator and related technologies.

   Summarize the results of research by drawing diagrams and using other strategies provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

LEARNING OBJECTIVE

Describes basic principles of electrical resistance, and gives examples of their application in:
- **selecting appropriate conductors**
- **electrical technologies designed to produce light and heat.**

1. Design and perform experiments that will identify:

   - good and poor conductors of electricity
   - factors that determine electrical resistance within a conductor.

2. Construct several simple circuits using conductors of varying:

   - type
   - length
   - diameter.

   Measure and compare the passage of electricity in each of these circuits.

3. Provide opportunities for students to:

   - disassemble/analyze non-functional appliances that produce heat or light (e.g., toaster, hair dryer, lamp). Determine how these appliances work, what is wrong with them, and repair them if possible
   - devise/construct simple technologies that use electrical resistance to produce heat and light.

   Strategies for solving technological problems of this nature are provided in The Relationship Between Science and Technology, "A Model for Technological Problem Solving".

4. Ask students to identify some beneficial and harmful effects of electrical resistance. Through discussion and related activities, encourage students to apply their knowledge of electrical resistance in:

   - understanding the operation of electrical-thermal technologies
   - selecting appropriate wire size/lamp size when maintaining/repairing/constructing simple devices
   - recognizing potentially dangerous situations that may occur as a result of using inappropriate conductors.

LEARNING OBJECTIVE

Demonstrates, through sketches/assembly/construction, an understanding of basic household circuitry:
- **series and parallel circuits**
- **conductors and insulators**
- **switches**
- **short circuits**
- **safety features (e.g., grounding devices, fuses/circuit breakers).**

1. Construct a series circuit and a parallel circuit using:

   - two 6-volt batteries
   - two 6-volt bulbs
   - two switches.

   Measure and compare electrical passage in the two circuits.

   Draw a diagram of each circuit, identifying conductors, insulators and switches. Trace the energy flow in each circuit. Discuss the advantages/disadvantages and applications of each type of circuit.

2. Construct a simple closed circuit using dry cells, bulbs and a switch. Produce a short circuit by using a screwdriver or other metal object. Observe the results.

   Discuss the dangers of short circuits/overloaded circuits, and the safety provided by fuses and circuit breakers.

3. Obtain a variety of fuses/circuit breakers. Disassemble these devices in an attempt to determine how they work. Draw diagrams that illustrate principles governing their operation.

   Discuss the location and function of fuses/circuit breakers in:

   - the home electrical system
   - an electrical appliance (e.g., electric stove).

4. Construct a diagram/model of a house that illustrates the location of major appliances, lights and electrical receptacles. Ask an electrician to explain to students how electrical circuits might be arranged in this house.

5. Encourage students to bring old/non-functional extension cords, appliance plugs and battery-operated toys to class. Ask students to determine what is wrong with these devices, and to make simple and safe repairs.

LEARNING OBJECTIVE

Relates principles of magnetism and electricity to the operation of familiar electrical technologies (e.g., door bell, electric motor, electric toys/games, kitchen appliances, hair dryer).

1. Collect a variety of electric door bells/buzzers for investigation by the class. Ask students to:

   a. Remove the outer casing from each of these devices.
   b. Examine and sketch the electrical circuitry/component parts of each device.
   c. Attach each device to a dry cell. Observe what happens as electrical energy travels through the device.

2. Investigate the use of electromagnets in:

   - an electric motor
   - a telephone
   - a television/radio speaker
   - buzzers/chimes.

   Discuss principles of magnetism and electricity as they relate to the operation of these and other familiar technologies.

3. Provide opportunities for students to design/construct electrical technologies that serve useful functions. Such technologies might include:

   - a door bell
   - a burglar alarm
   - an automatic door opener
   - an electrical puzzle box/game of skill
   - a crane.

   Discuss alternative designs that are suggested by students. Evaluate these technologies on the basis of their usefulness, efficiency of design, and ease of servicing/repair.

4. Select a variety of activities that will, encourage students to recognize:

   - the relationship between science and technology
   - the role of scientists and engineers in technological design and problem solving.

   Learning activities that illustrate these relationships are provided in The Relationship Between Science and Technology, "Understanding Science and Technology".

LEARNING OBJECTIVES

Illustrates energy flow and transformation in familiar electrical technologies.

1. Obtain several simple electrical devices that are used in the home (e.g., toaster, electric lamp, blender). Disassemble each device and:

   - trace energy flow
   - describe energy transformation.

   Using diagrams and flow charts, summarize the results of each investigation.

2. Investigate the method by which electrical energy is produced in the local community. Trace energy flow and transformation in this electrical system from the generating plant to your home.

3. Students may experience difficulty in using technical vocabulary related to the investigations outlined in this theme. Provide support for vocabulary development by relating new words to personal experience whenever possible.

   Additional suggestions for developing vocabulary in this theme are provided in Communication Skills, "Developing Technical Vocabulary".

LEARNING OBJECTIVE

Recognizes hazards inherent in the use of electricity:
- **identifies potentially dangerous situations**
- **predicts possible consequences of unsafe habits/routines.**

1. Encourage students to become aware of hazards inherent in the use of electricity by discussing and identifying:

   - situations/conditions that increase the danger of electrical shock
   - the need for electrical grounding devices
   - the hazards of short circuits
   - possible consequences of using inappropriate fuses
   - steps to follow in the event of an electrical accident.

   Invite a paramedic, doctor or representative from the local electrical utility company to discuss potential hazards related to the use of electricity, and to identify related safety practices.

2. Through discussion and brainstorming, formulate guidelines for the safe use of electrical technologies in the home. The guidelines may:

   - take the form of a list of "do's" and "don'ts"
   - relate to the use of electricity within specific areas of the home (e.g., bathroom, kitchen).

3. Conduct a walking tour of the school/community. Identify:

   - conditions/situations that may cause an electrical accident
   - possible consequences of an electrical accident in these situations
   - strategies for eliminating/avoiding these electrical hazards.

LEARNING OBJECTIVE

Monitors personal consumption of electrical energy in the home, recognizing strategies that will ensure its efficient use.

1. Encourage students to recognize the variety of ways in which their daily activities depend upon the use of electrical energy. Construct log sheets and ask students to record the different ways in which they use electricity during one day. Provide opportunities for students to discuss and compare their completed logs.

   CLARIFICATION/EXAMPLE

TIME	ACTIVITY	ELECTRICAL DEVICE USED
	wake up	clock radio
	shower	electric hot water heater
	breakfast	toaster, electric stove

   Ask students to monitor their use of electricity by completing the activities provided in Resource 1: An Electrical Survey.

2. Take an inventory of electrical consumption in the home. Rank the appliances listed below, using the numbers from 1 to 10, according to the amount of electrical energy you think they use (e.g., 1 = the least energy consumed, 10 = the most energy consumed). Then determine the actual ranking of these appliances by using consumption rates provided in pamphlets available from local utility companies.

APPLIANCE	YOUR RANKING	ACTUAL RANKING
Hair Dryer		
Refrigerator/Freezer		
Coffeemaker		
Television		
Dishwasher		
Clothes Dryer		
Washing Machine		
Toaster		
Microwave Oven		
Electric Stove		

Discuss results and identify:

- those appliances that are "high energy users"
- strategies that may be effective in reducing electrical energy consumed in the home.

3. Invite a guest speaker from the local electrical utility company to discuss strategies for:

- monitoring consumption of electrical energy in the home
- determining the cost of electrical energy used in the home.

Encourage students to read their household electric meters, and to keep daily/weekly/monthly records of electrical consumption. Students may wish to calculate energy costs on the basis of these records, and to compare their calculations to those provided on statements received from the utility company.

RESOURCE 1: AN ELECTRICAL SURVEY

A. Electrical Devices

Identify all the devices in your home that use electricity and classify them according to the categories provided below.

ESSENTIAL DEVICES	DEVICES THAT ARE NICE TO HAVE (could do without, but with difficulty)	UNNECESSARY DEVICES

B. Discussion Questions

1. Examine the technologies listed in Column 1. What did people do before electricity was available? Are you sure these devices are essential?

_____

_____

2. How can you monitor electrical consumption in your home? How much electricity does your home use in a day? Month? Year?

_____

_____

3. What are some practical ways that you can decrease electrical consumption in your home? Try these ideas and evaluate their effectiveness by monitoring your home's electrical consumption.

_____

_____

THEME D

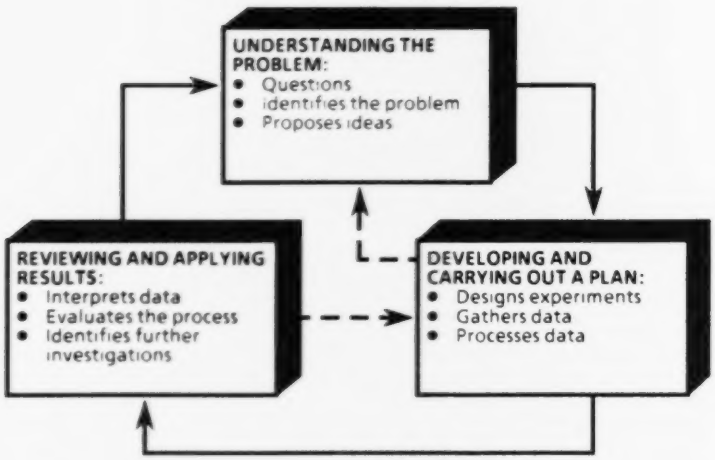
DIVERSITY OF LIVING THINGS

This topic will enable students to recognize the diversity that exists among living things present in the immediate environment. Investigations will emphasize interrelationships among living things and their environment, and will develop an understanding of how organisms interact, adapt, compete and change. Activities will provide opportunity for students to design and conduct their own scientific investigations of plant and animal adaptations. Students will also acquire a knowledge of how scientific classification is used to organize and structure the diversity present in living things.

Teachers are encouraged to reference the "Generic Strategies" provided in this manual when planning for instruction. Strategies particularly relevant to the learning objectives and activities outlined in this theme can be found in:

- The Nature of Science
- The Relationship Between Science and Technology
- Communication Skills
- Evaluation.

A MODEL FOR CONDUCTING SCIENTIFIC INQUIRY



CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

- Illustrates, through example, diversity in living things present in the immediate environment:
  - diversity in size/shape
  - diversity in physical structure.
- Identifies adaptive structures and behaviours of local organisms that enable them to survive in their environments.
- Recognizes that diversity in living things has been caused by the adaptive response of organisms to their environment.
- Recognizes that organisms may become extinct when there is lack of diversity/adaptation/specialization.
- Explains why the features of particular species of living things change over generations through the process of natural selection.
- Affirms the need to organize living things by classifying them into groups and sub-groups according to structural characteristics.
- Displays an understanding of systems used to classify living organisms:
  - Linnaean system of classification
  - recent developments in classification.
- Describes the diverse stages/forms of life in the life cycles of organisms common to the local environment:
  - complete metamorphosis
  - incomplete metamorphosis.
- Recognizes how certain species perform diverse tasks/functions through the use of specialized structures and appendages:
  - social insects
  - human body.

SKILLS

- Uses appropriate inquiry skills to gather, process and interpret information related to the adaptations/relatedness of local plants and animals:
  - observes/counts/measures
  - identifies variables
  - infers relationships
  - uses charts/tables/diagrams
  - makes predictions.
- Performs a plant and animal census within a given plot in the local community, observing and inferring:
  - structural features of plants and animals
  - the adaptive value of particular structures/behaviours
  - similarities/differences in the overall structure of particular groups of plants and animals
  - environmental conditions that affect the survival and distribution of particular species.

SKILLS (continued)

- Uses classification skills:
  - classifies materials/objects by dichotomous grouping
  - constructs/applies a dichotomous key
  - uses a classification key in identifying local plants and animals
  - classifies familiar organisms by major scientific groups (e.g., kingdom, phylum).
- Follows appropriate procedures in caring for plants and animals.
- Uses appropriate strategies in gathering data related to:
  - diversity in the developmental stages/life cycles of major plant and animal groups
  - diversity in the tasks performed by similar species through use of specialized structures.
- Uses decision-making skills in evaluating the effects of human action/intervention on the diversity and distribution of local plants and animals.

ATTITUDES

- Displays a positive attitude toward self and the study of science:
  - assumes responsibility for personal conduct
  - performs investigations and completes assignments independently and in cooperation with others
  - practises strategies for resolving interpersonal conflict
  - shows interest and curiosity through willingness to ask questions/share observations and ideas/seek answers.
- Develops an awareness and appreciation of the diversity and interrelatedness of life forms.
- Develops a sensitivity for the delicate balance among living things and their environment.
- Appreciates the usefulness of scientific systems of classification.
- Values the use of scientific inquiry in acquiring knowledge of natural phenomena.
- Develops confidence in personal ability to conduct scientific investigations of living things.

INTEGRATION ACTIVITIES

LANGUAGE ARTS

Students will use a variety of communication skills throughout activities in this theme. Instructional activities will require students to:

- develop technical vocabulary related to the interaction, adaptation and competition that exists among local living organisms
- give and follow directions when designing/conducting investigations
- use viewing/reporting/note-making skills when gathering, organizing and communicating data about plant and animal adaptations.

Teachers are encouraged to identify appropriate strategies for developing these skills through cooperative conferencing with teachers of language arts. Strategies for developing related skills are also provided in the "Communication Skills" section of this manual.

MATHEMATICS

Students will be using skills developed in mathematics class when they:

- measure length/mass/capacity/temperature
- classify and display data in table/chart form
- interpret/construct graphs.

Science teachers are encouraged to conference with the mathematics teacher in establishing appropriate strategies for applying mathematical concepts/skills. Plan activities that will enable students to use mathematics class to interpret and display the data they gather through experiments performed in science.

SOCIAL STUDIES

Students will develop an awareness of the importance of plant and animal life in the local environment. Students might:

- identify local problems/issues related to interrelationships among living things and their environment
- discuss the importance of government legislation in establishing controls that limit the potential effect of human activities on the natural environment (e.g., hunting/fishing regulations, control of the use of pesticides)
- identify potential career opportunities in plant/animal care
- compare/contrast the diversity of living things that exists in Canada with those of the United States.

PRACTICAL ARTS

Conferencing among science and practical arts teachers will assist in identifying thematic concepts/skills that have application in the students' practical arts program. Integration activities may provide opportunities for students to recognize:

- the potential impact of inappropriate methods of waste disposal on local plant/animal populations
- the effects of herbicides/pesticides on balance among living things and their environment
- employment opportunities in areas related to horticulture, agriculture and environmental care.

COMMUNITY PARTNERSHIP OPPORTUNITIES

- Plan a field trip to a local field/woodlot. Note the diversity and characteristics of plants and animals that are present. Ask students to:
  - identify/classify the plants and animals they observe
  - describe special adaptive structures/behaviours that enable these organisms to survive.

- Invite a wildlife officer to speak to the class about:
  - adaptive structures/behaviours of local organisms
  - how seasonal/climatic changes may affect plants and animals.

- Visit a local greenhouse/nursery/wildlife reserve/zoo, noting:
  - diversity and characteristics of plants/animals
  - special adaptations/behaviours that enable organisms to survive in their environment
  - appropriate care procedures for plants/animals.

- Invite a horticulturalist/veterinarian to explain how controlled breeding programs have changed the characteristics/adaptations of certain plant and animal species.

- Plan a field trip to a museum of natural history. Ask the curator to explain how natural selection has produced changes in the characteristics of plants and animals found in the local environment.

- Visit a local archaeological site and observe the fossilized remains of primitive plants and animals. Identify and discuss:
  - specialized structures/appendages exhibited by primitive organisms
  - factors that may have caused primitive organisms to become extinct.

- Interview a local resident who can describe changes that have occurred in the diversity/distribution of plants and animals found in the surrounding area over the last decade.

- Invite an agriculturalist/farmer to discuss biological and chemical methods of controlling insect pests (e.g., grasshopper, mosquito), and to explain how control methods:
  - often require knowledge of the life cycle of insects
  - may have an adverse effect on other wild/domestic organisms in the local area.

- Visit a local apiary and observe the social structure of bees living within each hive. Ask the apiarist to explain the diverse tasks/functions performed by the queen, drone and worker bees.

- Obtain information from local wildlife societies about plant/animal species currently threatened by extinction. Identify:
  - factors that have caused these species to become "endangered"
  - strategies that may ensure the survival of these species.

- Invite a biologist to speak to the class about the use of classification keys in identifying local plants and animals. Ask this person to discuss the advantages/disadvantages of different classification systems.

- Invite a representative from the local SPCA (or pet store) to explain:
  - how domesticated animals often develop adaptive behaviours that make them dependent upon human care for survival
  - appropriate procedures to follow in caring for pets.

BASIC RESOURCE CORRELATION

Science Plus Technology and Society 9
- Unit: Diversity of Living Things

SUGGESTED ACTIVITIES

Science Plus Technology and Society 9 and its corresponding *Teacher Resource Book* provide a variety of activity-based investigations that support the learning objectives identified in this theme. The activities that follow may be used to supplement those provided in the basic learning resource. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

Illustrates, through example, diversity in living things present in the immediate environment:
- **diversity in size/shape**
- **diversity in physical structure.**

1. Observe a variety of different kinds of animals present in the immediate environment. Compare and contrast these organisms in terms of:

   - size/shape/colour
   - habitat
   - adaptive structures/methods of survival.

   Attribute guides are useful in establishing a structure for observing living organisms. A sample attribute guide is provided in The Nature of Science, "Gathering Data".

2. Collect a variety of plant specimens found in different locations within the local community. Compare and contrast these plant specimens in terms of:

   - size/shape/colouration
   - physical structure of leaves, stem, root, flower
   - adaptive structures/methods of survival.

3. Identify plant and animal populations found within:

   - a natural environment (e.g., a local field or woodlot)
   - a human-controlled environment (e.g., the local community).

   Compare the diversity of plant and animal populations found within these two regions. Discuss environmental factors that may affect diversity among populations of living organisms.

LEARNING OBJECTIVE

Identifies adaptive structures and behaviours of local organisms that enable them to survive in their environments.

1. Observe a variety of plant and animal structures and interpret the functions performed by these structures.

   e.g., - What functions do the antlers on a deer/antelope serve?
   - What special characteristics of the pine cone ensure that the pine tree will survive natural disasters (e.g., forest fires)?
   - What adaptive structures and behaviours of squirrels/bears enable these animals to survive in their environment throughout the year?
   - What special root/seed structures do common varieties of garden weeds have that ensure their survival?

2. Investigate how colouration is an adaptation that may ensure the survival of living organisms. Conduct the following activity:

   a. Obtain 30 toothpicks. Paint 15 toothpicks green and 15 toothpicks red.
   b. Randomly spread the 30 coloured toothpicks over a grassy area that is 4 square metres in size.
   c. With a partner, find as many toothpicks as possible within a 10 second period of time. Record the results.
   d. Repeat this process with the remaining toothpicks (i.e., surviving generations) three more times. Record results.

   Through discussion, relate the results of this activity to:

   - the role of colour in camouflage
   - predator/prey relationships.

3. The mouthparts of an insect are an adaptation that enable the insect to eat special kinds of food. Further investigate this adaptation by:

   - observing the mouthparts on a variety of different insects, using real or preserved specimens
   - identifying the kinds of food that each insect is most suited to eat
   - drawing diagrams that illustrate each insect and its mouthparts.

LEARNING OBJECTIVE

Recognizes that diversity in living things has been caused by the adaptive response of organisms to their environment.

1. Observe groups of plants or animals that are similar in their overall structure, but that have some identifiable variations. Through discussion, encourage students to infer:

   - the adaptive value of the structural variations they observe
   - environmental factors/conditions that may have caused these structural variations.

2. Discuss the following statement:

   "Each environment presents obstacles to the survival of its inhabitants. Living organisms must adapt and respond to these obstacles in order to survive."

   Observe a number of different habitats within the local environment (e.g., stream, woodlot, dry sunny area). For each habitat, ask students to identify:

   - plants/animals that live there
   - environmental obstacles that must be faced by organisms living there
   - adaptive responses of plants/animals to these obstacles.

3. Visit a local zoo or wildlife sanctuary. Carefully observe two or three animals, making note of:

   - adaptive structures/behaviours that are unique to each animal
   - the function served by each adaptation
   - environmental factors/conditions that may have caused each adaptation.

LEARNING OBJECTIVE

Recognize that organisms may become extinct when there is lack of diversity/adaptation/ specialization.

1. Some organisms are able to diversify and adapt to factors in their environment very well. Other organisms, however, are less able to do so and may become endangered or extinct. Identify local populations of living things that have:

   - increased in number to the degree that the species has become over-abundant and is a "pest"
   - decreased in number to the degree that the species has become "endangered" or "extinct".

   Encourage students to suggest environmental factors that may have caused these populations to increase/decrease, and adaptive structures/behaviours that the species were/were not able to develop.

2. Identify local practices/activities that may affect interaction and balance among living organisms:

   - use of pesticides
   - hunting/fishing
   - pollution and waste disposal
   - urban development.

   Ask students to suggest reasons why some species of plants/animals are able to survive in urban areas, while others are not.

3. Obtain information from local wildlife agencies about plant/animal species that are currently threatened by extinction. Identify:

   - factors that have caused these species to become endangered
   - strategies that may ensure the survival of these species.

LEARNING OBJECTIVE

Explains why the features of particular species of living things change over generations through the process of natural selection.

1. Investigate how natural selection may cause the characteristics of plant/animal species to change by performing the activities outlined in:

   - Resource 1: Natural Selection in Plants
   - Resource 2: Natural Selection in Animals.

2. Identify ways in which natural selection has produced changes in the characteristics of local plants and animals by:

   - visiting a museum of natural history. Ask the curator to illustrate/explain changes that have occurred in local plant and animal species over the last 100 years
   - interviewing a senior citizen in the local community. Ask this person to describe changes they have noticed in the distribution//characteristics of plants and animals found in the surrounding area over several decades.

3. Relate the concept of natural selection to controlled breeding programs that are used to develop specialized features/characteristics in plants and animals.

   Identify specific characteristics of plants/animals that may be developed through controlled breeding:

   - resistance to disease/adverse weather conditions
   - improved quality/yield (e.g., seedless grapes, dairy cattle)
   - aesthetic qualities (e.g., ornamental shrubs, domestic pets).

4. Invite an agriculturalist/horticulturalist/veterinarian to explain how controlled breeding has been used to produce desirable characteristics in:

   - local livestock
   - farm and garden plants
   - domestic pets.

LEARNING OBJECTIVE

Affirms the need to organize living things by classifying them into groups and sub-groups according to structural characteristics.

1. Identify a variety of everyday classification systems:

   - telephone book
   - library organization
   - dictionary
   - merchandise display in the supermarket/department store.

Encourage students to become aware of the value of classification systems, and the criteria upon which various classification systems are based.

2. Provide opportunities for students to develop/use a dichotomous classification system through the activities provided in Resource 3: Classifying Strange Shapes.

   Additional suggestions for developing classification systems are provided in The Nature of Science, "Processing Data".

3. Through brainstorming, make a list of familiar sports activities. Divide students into groups of two or three. Ask each group of students to sort/classify these sports according to criteria established by the group. Provide opportunities for each group of students to share their results with the class. Discuss possible advantages/uses of each type of classification system established by students.

4. Gather a variety of leaf/foliage specimens. Ask students, individually or in small groups, to design a dichotomous classification key that could be used to identify and describe these leaves. Characteristics that might be used to classify leaves include:

   - deciduous/coniferous
   - broad/narrow leaf
   - vein structure
   - general shape.

   Discuss differences among the classification keys used by students. Ask students to use their classification key to prepare a display of locally-gathered leaves.

5. Investigate how Statistics Canada groups or classifies people when reporting census results.

LEARNING OBJECTIVE

Displays an understanding of systems used to classify living organisms:
- **Linnaean system of classification**
- **recent developments in classification.**

1. Design a chart that illustrates groupings that are frequently used in classifying animals. Ask students to classify a variety of familiar animals using these groupings.

e.g.,	Invertebrate Groups	Vertebrate Groups
	Annelids	Fish
	Molluscs	Amphibians
	Echinoderms	Reptiles
	Arthropods	Birds
	Others	Mammals

Students may have difficulty classifying these animals if they are unfamiliar with structural characteristics or do not have an opportunity to observe them. Preserved specimens and close-up pictures will be very useful in this activity.

Do not require students to memorize lists of animals that fit into each of these groups. Provide enough information about each animal so that students can easily place it in an appropriate group.

2. Discuss the work of the Swedish scientist, Carlus Linnaeus, and the Linnaean system of classification. Ask students to draw a chart that illustrates the Linnaean system of classification.

   Compare this system of classification to systems of classification used by most scientists today.

3. As an enrichment activity, use the Linnaean system of classification to describe several familiar animals (e.g., dog, horse, human) by naming:

   - Kingdom
   - Phylum
   - Class
   - Order
   - Family
   - Genus
   - Species.

LEARNING OBJECTIVE

Describes the diverse stages/forms of life in the life cycles of organisms common to the local environment:
- **complete metamorphosis**
- **incomplete metamorphosis.**

1. Investigate the life cycles of insect pests found in the local environment (e.g., housefly, grasshopper, mosquito). Illustrate metamorphic stages within the life cycles of these insects by drawing pictures/diagrams.

   Invite an agriculturalist/farmer to discuss biological and chemical methods of controlling insect pests that are based on a knowledge of each insect's life cycle.

2. Compare and contrast developmental stages in the life cycles of insects that undergo complete metamorphosis (e.g., butterfly, bee, mosquito) with developmental stages in the life cycles of insects that undergo incomplete metamorphosis (e.g., grasshopper, cicada, praying mantis). Describe differences among the developmental stages that these insects undergo.

3. Provide opportunities for students to investigate and observe the developmental stages of several aquatic/terrestrial vertebrates.

   e.g., – observe/record the development of frog's eggs in an aquarium
   – observe the development of a young mammal (e.g., mouse, gerbil)
   – incubate several fertilized hen's eggs and observe/record the growth of young chicks.

LEARNING OBJECTIVE

Recognizes how certain species perform diverse tasks/functions through the use of specialized structures and appendages:
- **social insects**
- **human body.**

1. Investigate the social structure of bees living in a hive. Describe how the queen bee, drones and worker bees perform diverse tasks/functions through the use of specialized structures.

   Visit a local apiary and observe an active hive. Ask the apiarist to discuss:

   - the life cycle of the bee
   - the tasks/functions performed by the queen bee, drones and worker bees.

2. Investigate social structure that exists within an ant colony. Observe the specialized structures/ appendages of several preserved ant specimens. Discuss the use of these structures in performing tasks essential to the survival of an ant colony.

   Students may wish to establish an ant colony within the classroom, and observe:

   - specialized structures possessed by different members of the ant colony
   - diverse tasks/functions performed by the queen, male and worker ants.

3. Compare and contrast life in a community of social insects (e.g., a bee hive or ant colony) with life in the students' community. Encourage students to recognize that the survival of their community also depends upon members performing diverse tasks/jobs.

4. Discuss ways in which the human body is able to perform diverse tasks/functions through the use of specialized structures. Identify/describe:

   - specialized structures within the human body and the unique tasks/functions they enable humans to perform
   - how the loss of certain structures/appendages may affect human survival.

5. Discuss and debate the following statement:

   "It is unlikely that the housefly will ever become extinct because its many specialized structures/ appendages make it well suited to most environments."

   Structure discussion and debate using suggestions provided in Communication Skills, "Strategies for Discussing and Debating".

RESOURCE 1: NATURAL SELECTION IN PLANTS

Natural selection occurs in many ways. In an experiment, a field was seeded with grass seed. One-half of the field was fenced off and the grass allowed to grow to full height so that it could be cut and dried to make hay. The other half of the grass field was used as a pasture. This pattern was continued for three years (e.g., one-half of the field was grown for hay and the other half was used as pasture). During the fourth year, seeds were taken from both halves of the field and planted. What do you think the grass grown from these seeds looked like?

Grass from the part of the field used for pasture was short and rambling. For three years, the tall grass in the pasture was eaten by animals. This grass stood tall and erect and could be easily eaten. Most of the short, rambling grass escaped being eaten because it grew close to the ground. Thus, the short grass in the pasture area lived to produce seeds for the next crop of grass. The next generation of grass in the pasture resembled its parents. It was short and rambling.

Grass from the part of the field used for hay was tall and straight. Seeds from the hay field produced plants that were tall and straight. Tall plants received the sunlight needed to make food. They grew until they reached maturity. Short plants in the hay field were shaded by the tall plants. They did not get enough sunlight. The tall grass survived each year in the hay field. The short grass died.

ACTIVITY

1. Organize the information provided about this experiment under the following headings:

   - Problem _____
     _____
   - Procedure _____
     _____
     _____
     _____
   - Observation _____
     _____
     _____
     _____
   - Conclusion _____
     _____
     _____
     _____

2. State a hypothesis for this experiment. Explain how the hypothesis is supported by the observations.

3. How does this experiment illustrate natural selection?

4. Identify ways in which natural selection has changed other species of plants.

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RESOURCE 2: NATURAL SELECTION IN ANIMALS

There are some insects in England called peppered moths. These moths are often found on tree trunks and are eaten by birds. In the following activity, you will discover how natural selection may affect the colour of these moths.

ACTIVITY

a. Mix 20 light- and 20 dark-coloured chips in an envelope. The chips represent light- and dark-coloured peppered moths.
b. You are a moth-eating bird. While your partner holds the envelope, reach in and pull out the first moth you see. Do this ten times. Count the light and dark moths you have eaten.
c. Replace the moths in the envelope. Change places with your partner. Add your partner's moth count to yours.

DISCUSSION QUESTIONS

1. Did you and your partner eat more light-coloured moths or dark-coloured moths?

   _____

2. How would you explain this? _____

   _____

3. What effect would this have on succeeding generations of moths?

   _____

   _____

NATURE HAS FAVOURITES

This experiment is for real. A hundred years ago most of the peppered moths in England were light-coloured. The tree trunks were light-coloured too. Light moths were safely hidden on the light-coloured trees. The moths survived and had offspring. Dark-coloured moths were also born, but the birds easily caught them. Natural conditions were in favour of the light moths. We can say that nature "selected" light moths to survive.

RESOURCE 2: NATURAL SELECTION IN ANIMALS (continued)

Nature doesn't have permanent favourites. Under different conditions natural selection favours dark moths. Factories that poured out black smoke were build in England. Many tree trunks turned dark.

1. Which moths now showed up against the tree trunks and were eaten?

   _____

   _____

2. Which moths survived and had offspring?

   _____

   _____

3. How did natural selection now favour the dark moths?

   _____

   _____

RESOURCE 3: CLASSIFYING STRANGE SHAPES

A. Imagine that the shapes shown on the following page are types of organisms found on a strange planet. Develop a way to group or classify them. Examine the organisms carefully. Notice that they look alike in some ways and different in others. In other words, they have some characteristics that are similar and others that are different. Shape and colour are just two of these characteristics. Cut out each of the organisms. Choose **one** major difference among the organisms.

Which characteristics did you choose? _____

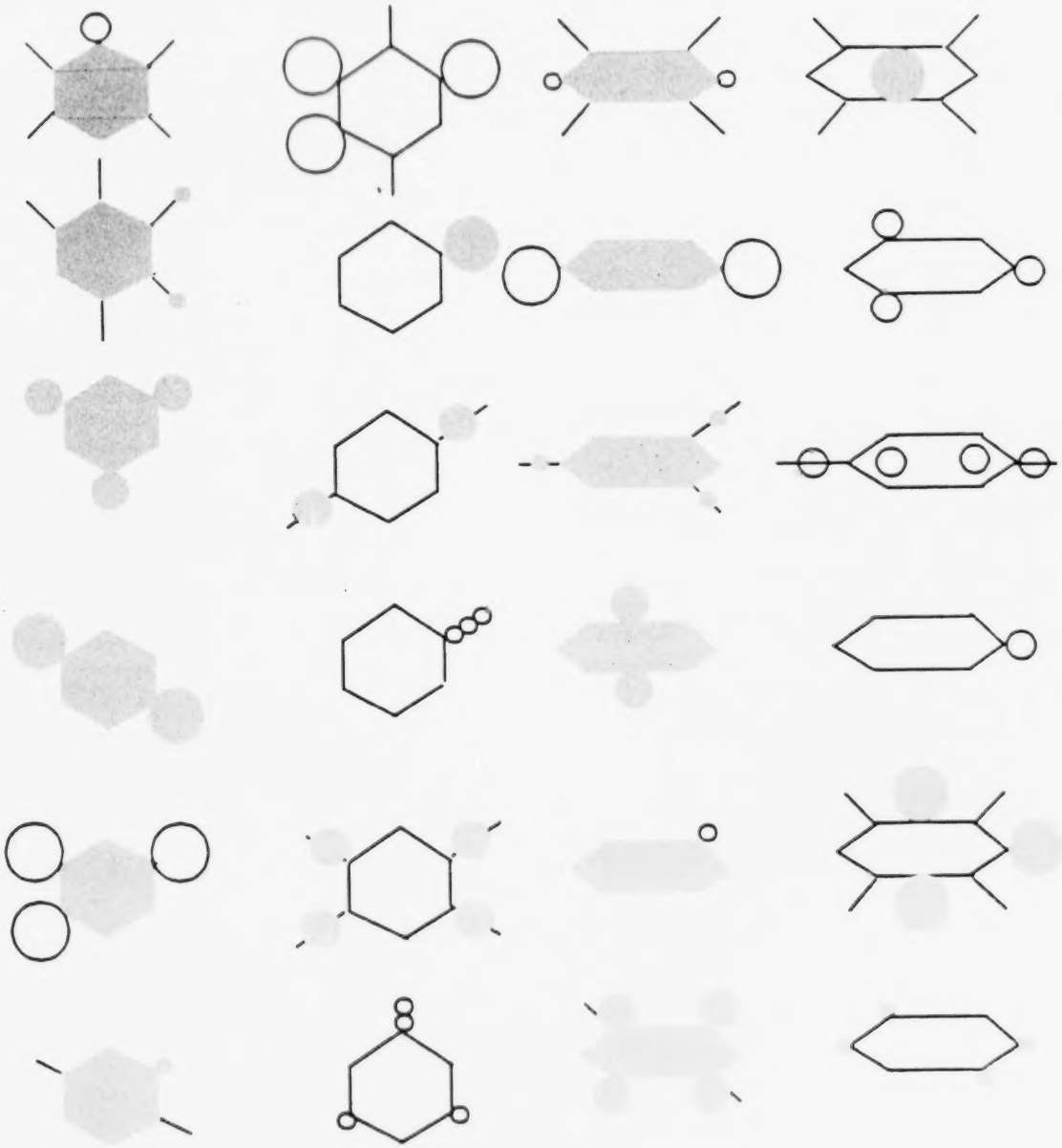
_____

B. Separate the organisms into two groups based on this characteristic. Be sure that all the organisms in the same group have the same characteristic.

C. Now put all the organisms back together in a pile. Separate the organisms into two groups based on different characteristics. Keep doing this until you run out of differences between the organisms. Be sure to put the organisms back together each time. Make a list of the differences you found.

1. _____
   _____
2. _____
   _____
3. _____
   _____
4. _____
   _____
5. _____
   _____
6. _____
   _____
7. _____
   _____

D. It is possible to use the differences to develop a classification system for these organisms. To do this, choose one characteristic from the list. Separate the organisms into two groups using this characteristic. Call one group A, the other B. Choose a second characteristic from the list. Separate the organisms in group A into two sub-groups based on this new characteristic. Then repeat this procedure for group B.



THE NATURE OF SCIENCE

Learning to understand natural objects and events, and to apply knowledge gained to a variety of real life situations is emphasized throughout the science program. Today's society requires that students are active investigators, possessing the critical and creative thinking skills that will enable them to interpret and evaluate information gathered through the senses. A focus on the nature of science and the inquiry process will enable students to understand the way in which scientific knowledge is gathered, as well as use this knowledge in conducting investigations of their own.

Learning activities used throughout the science program will enable the student to recognize:

- that science is a disciplined way to develop explanations for the events and objects of the natural world
- that science is comprised not only of an accumulated body of knowledge, but also of the processes by which that knowledge is developed
- how scientific knowledge is gathered through observation and experiment
- why scientific knowledge is not certain, but based on theory which may change as additional evidence accumulates.

Through the selection of appropriate activities and materials, the science program should encourage students to display:

- curiosity about events and objects in the natural world
- an appreciation of the beauty and complexity of the natural world
- a concern for accuracy and supporting evidence
- honesty and completeness in reporting and evaluating evidence
- open-mindedness in considering alternative ideas and interpretations
- critical mindedness in evaluating inferences and conclusions
- confidence in personal ability to design and conduct a scientific investigation.

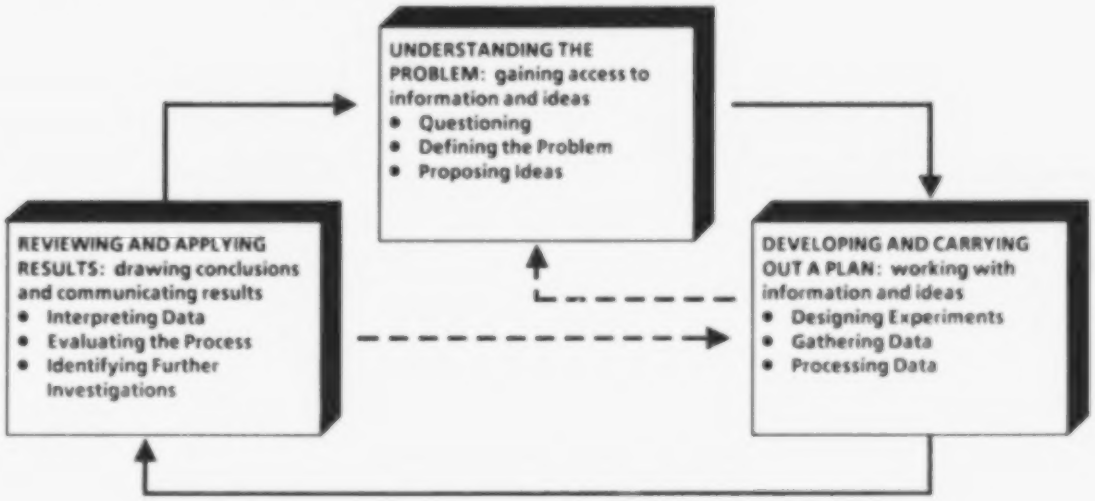
A variety of teaching and learning strategies that may be used in nurturing an understanding of the nature of science have been included in this section of the manual. The strategies support active involvement in the inquiry and problem-solving processes, and include:

- A Model for Scientific Inquiry
- Strategies for Developing the Inquiry Skills
  - Understanding the Problem
  - Developing and Carrying Out a Plan
  - Reviewing and Applying Results
- Suggestions for Using the Inquiry Model
- A Sample Lesson Plan.

A MODEL FOR SCIENTIFIC INQUIRY

Critical to the development of the inquiry process is the attitude with which students approach an investigation. People are often uneasy and hesitant to involve themselves in situations where procedures are not easily determined and outcomes are not evident. Appropriate attitudes must be nurtured through an atmosphere that provides encouragement, flexibility and acceptance. Discussion and activity should foster student curiosity about natural events and an interest in trying to understand them. Students must be persuaded to take risks in planning investigative procedures, and to develop a concern for accuracy, honesty and evidence in the investigations they perform. Students will be supported in their understanding of the inquiry process when investigations are selected that relate to personal experience, interest and need.

This model for scientific inquiry suggests an overall process for attacking investigation. It provides a starting point and some ways of organizing efforts.


UNDERSTANDING THE PROBLEM: gaining access to information and ideas
• Questioning
• Defining the Problem
• Proposing Ideas
DEVELOPING AND CARRYING OUT A PLAN: working with information and ideas
• Designing Experiments
• Gathering Data
• Processing Data
REVIEWING AND APPLYING RESULTS: drawing conclusions and communicating results
• Interpreting Data
• Evaluating the Process
• Identifying Further Investigations

Specific actions identified at each stage of the inquiry process represent possible strategies that might be used in conducting an investigation. Students may not always use each stage of the process, and will select only those actions that are appropriate to purpose and ability. Students should, however, recognize inquiry as a series of interrelated actions that lead to an outcome.

By bringing thought processes to the metacognitive level (i.e., helping students to become aware of the thinking skills and thought processes that they and others use), students will be better able consciously to select and use those strategies and skills that are appropriate to the situations they encounter. Research strongly supports the teaching practice of:

- modelling (talking through) the processes and skills that are appropriate to an investigation
- discussing the processes and skills that the student is presently in the habit of using (i.e., raising the level of metacognitive awareness)
- encouraging students to develop additional strategies that will structure and support the thought process.

The model for inquiry should be explicitly presented to students as an overall process, and then be constantly used as a teaching and learning model.

STRATEGIES FOR DEVELOPING THE INQUIRY SKILLS

The inquiry skills are individual mental skills that enable the student to participate actively in the inquiry process. Students will develop an awareness of, and receive instruction in the use of the inquiry skills identified below. Learner ability will determine the degree to which each skill is independently applied in the inquiry process.

UNDERSTANDING THE PROBLEM	DEVELOPING AND CARRYING OUT A PLAN	REVIEWING AND APPLYING RESULTS
• Questioning – recognizes patterns/ discrepant events – formulates questions	• Designing Experiments – plans appropriate procedures for testing predictions/hypotheses – identifies and controls variables – selects appropriate materials/apparatus	• Interpreting Data – infers relationships – identifies cause and effect – creates models/analogies to explain ideas – applies discovered knowledge
• Defining the Problem – identifies factors relevant to a problem – defines the problem	• Gathering Data – makes observations through direct use of the senses – uses specialized tools of observation – uses appropriate measuring tools/units/ procedures – makes estimates – accurately records data that is gathered	• Evaluating the Process – assesses procedures/ thought processes used – considers adequacy of data in supporting inferences made
• Proposing Ideas – generates ideas about possible relationships – makes predictions – formulates hypotheses	• Processing Data – organizes data by comparing/ordering/ classifying/calculating – summarizes/displays data using simple charts and graphs – identifies patterns/trends	• Identifying Further Investigations – seeks further evidence – formulates additional questions – defines new problems

Student learning styles suggest that inquiry skills will be most effectively learned through active involvement in the inquiry and problem-solving process. Select instructional activities that:

- support a student-centered learning environment
- are investigative rather than didactic.

Suggestions for planning investigative activities that nurture the development and use of inquiry skills are provided on the pages that follow.

UNDERSTANDING THE PROBLEM

QUESTIONING/DEFINING THE PROBLEM

> Questioning recognizes the need of the student to take an active role in initiating an investigation. Questioning may originate when the student recognizes a discrepant or unexplained event in the environment. Skill in questioning is built on the student developing ability to reflect on the discrepant event, to analyze the event in light of previous experience, and to formulate questions in a way that probes for specific meaning or knowledge. Initially the student may ask questions in terms that are difficult to answer, but with guidance and practice learns to evaluate, rephrase and redirect questions so that answers can be found, often on one's own. Questioning skill leads to skill in problem definition, a step which the student takes in assuming increased responsibility for finding answers.[1]

Questioning techniques modelled by the teacher are effective in developing an awareness of, and ability to ask relevant questions. In preparing for an activity, teachers should:

- begin with divergent questions so as to allow for a large number of answers and to provide for critical/creative thinking
- use convergent questions if students seem to be having difficulty
- ask questions that require students to engage in thinking at all levels (e.g., recall, application, analysis, synthesis, evaluation)
- encourage participation and thought by allowing an appropriate "response time" for each question that is asked.

CLARIFICATION/EXAMPLE

Questions That Involve Students in Investigation

- What are we looking for?
- What do we want to explain/investigate?
- What do you notice about this ...?
- What do you think might happen if ...?
- Why did ...?
- What should we do first?
- What is stopping us?
- If this is so, then ...?

Questions That Stimulate Creative Response

- What is my next step?
- How will I do that?
- How can I design a better ...?
- What is the relationship between ... and ...?
- Why did ... happen after ...?
- How would you design an experiment to ...?
- What might happen if you use ... instead of ...?
- What is the likelihood that ...?

1. Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, p. 18, 1983.

CLARIFICATION/EXAMPLE

Questions That Stimulate Analysis and Evaluation

- How did you know that ...?
- What does the data indicate?
- What caused ... to happen?
- How does ... apply to ...?
- How could you explain ... in another way?
- How might you use these results?
- How could we make our work easier another time?
- How could we improve it or make it better?
- What should we tell others?

Students should be given frequent opportunity to generate questions that are based upon the observations they make and the information they gather. The strategy that follows may be useful in developing student ability to formulate questions related to information they have read. Teachers may wish to modify this strategy according to the nature of the investigation and the information being examined.

CLARIFICATION/EXAMPLE

A Strategy for Generating Questions[1]

1. Provide students with a copy of some reading material.

2. Ask students to read the first paragraph silently. Monitor students to ensure that they have read the paragraph, by asking questions related to the outcome of the paragraph.

3. Ask students to go back to the beginning of the paragraph and silently read the first sentence again.

4. Encourage students to generate as many questions as possible, based upon the first sentence. The teacher should respond to each question asked.

5. Reverse the roles of student and teacher. The teacher now asks questions of the students, which are based upon the first sentence. Questions asked by the teacher should be in different categories to those asked by students (e.g., knowledge, comprehension, application, analysis, synthesis, evaluation). Students should answer each question asked by the teacher, or give a reason for not being able to answer. The teacher should provide responses for questions the students cannot answer.

1. Adapted from *SPELT: A Strategies Programme for Effective Learning and Thinking Inservice Edition*, SPELT International Ltd., p. 114. Copyright 1987 by R. Mulcahy, K. Marfo, D. Peat and J. Andrews. Reprinted by permission.

PROPOSING IDEAS

Strategies that establish a sense of direction to inquiry are identified in this skill area. Establishing a sense of direction is critically important to the inquiry process, for in science, answers to questions do not normally emerge spontaneously. Generally they emerge as the result of ideas that have been proposed and then tried to see if they work. The proposing of ideas is not always an external process, nor is it always done in a rational way. Ideas emerge out of a combination of reflection on what the learner already knows or supposes to be true. Whether by conscious rational thought, or by intuition, the student then takes the fundamental step of mentally associating two or more objects, events, properties and/or living things in the context of some type of relationship. The process of making this type of association may be a nearly instantaneous one, taking place in the fraction of a second after a question has been asked. For more difficult questions the process may be considerably extended, taking as long as several days or months, depending on the difficulty of the problem and the tenacity of the learner. Once "proposed", an idea may lead to formal investigation, or on further reflection may be rejected as unlikely or inappropriate. A number of ideas may be "proposed" within the student's mind, but only the most favoured one used to direct further thought and investigation.

The relationship between the two component skills of "hypothesizing" and "predicting" is a complex one. If we all thought on the basis of formal logic, it would seem necessary for us to hypothesize before we could predict, for it is only logical that we should recognize a relationship before we can apply that relationship to a prediction. In actual patterns of thought (and particularly for the student who has not advanced beyond a "concrete operational" stage), conscious thought may appear to transcend the step of hypothesizing and go directly to predicting. This does not mean that the student cannot and does not hypothesize. It may only mean that the student is incapable of reflecting on mental processes and is thus incapable of describing those processes to us. The ability to consciously reflect on an hypothesis and the related ability to state an hypothesis may not develop until relatively late in the student's school career. It is thus appropriate that a student's ability to hypothesize during the early years be gauged indirectly through ability to predict.[1]

Students should be encouraged to demonstrate initiative in identifying problems and proposing ideas that are based upon their personal observations of familiar objects/events. Arouse curiosity and guide students' thought through discussion and the use of appropriate questioning techniques (see "Questioning/Defining the Problem").

The statements that follow provide additional suggestions for developing student ability to generate ideas about possible relationships, and devise simple statements that can be tested by observation or experiment:

- Assist students to formulate questions/problems that arise from personal observations they have made. (e.g., Why did this group of plants grow so much taller than the others?)

1. Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, p. 18-19, 1983.

- Through discussion, generate ideas about possible relationships between objects/events that have been observed. (e.g., These plants may have grown taller because ....)

- Encourage students to describe the relationships they propose with simple statements. (e.g., If I do ....., then .... will happen.)

- Distinguish between guessing and predicting. Use patterns/trends/repeated observations to predict the next occurrence of an event. (e.g., According to previous observations, which of these plants would you expect to grow taller? What is the basis of your prediction?)

- Provide opportunity for students to confirm/reject predictions they make through observation, measurement or experiment.

- Coach students in devising tentative explanations by asking appropriate chains of questions. (e.g., What factors seem to affect the growth of plants? Can plant growth be maximized by ... ?)

- Do not expect students to formulate sophisticated hypotheses at this grade level. Rather, encourage students to select suitable hypotheses from sets of alternatives they are given. The abstract process of "hypothesizing" will be difficult for students who are functioning at a concrete level.

DEVELOPING AND CARRYING OUT A PLAN

DESIGNING EXPERIMENTS

> This skill area identifies those thoughts and actions by which the student tries out an idea that has been proposed. At an early level of skill, the student may not consciously reflect on the techniques used to "find out". Rather, the student may proceed directly to a procedure that fits the concept of what is needed to demonstrate the relationship already believed to exist. The tendency to jump to conclusions appears to be natural at early ages, with experience used only to support foregone conclusions rather than to evaluate them critically. It is only as the student advances in ability to think critically that reflective attention is given to the procedures used in experimenting. When the student reaches this stage, the concept of a fair test can be introduced. This concept can then be expanded by introduction of the related concepts of manipulated variable, responding variable and control variables.[1]

The process of designing an experiment is complex and requires the student to "plan" an investigation in order to obtain a solution to a problem or test an hypothesis. Planning an investigation requires the student to:

- identify the kinds of observations/measurements that are required to answer the question or problem. (e.g., If we were to investigate the idea that the amount of soil affects the growth of a plant, what should we do? What things would we want to measure? How should we measure them?)

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1. Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, p. 19, 1983.

- identify and control variables so as to make the experiment a "fair test" of the given question or problem. (e.g., Does it make any difference to the experiment if some plants are watered more frequently than others? What things should we do to make our experiment a fair test?)
- develop methods for collecting data and selecting apparatus and supplies that will be required
- devise sequential procedures to be followed and techniques for manipulating the apparatus and supplies
- decide upon the manner in which data will be recorded
- consider safety procedures that must be followed.

The process of designing an experiment might be initially illustrated through teacher demonstrations that involve relationships familiar to the student. Following these demonstrations, plan other investigations through discussions that involve the whole class. As students develop an understanding of the process of designing an experiment, provide opportunity for students to plan and conduct simple experiments of their own.

CLARIFICATION/EXAMPLE

A Sample Outline for Designing an Experiment

1. Ask a question.
2. Write an hypothesis that answers the question.
3. Plan procedures that will be used to verify the hypothesis:
   - identify one variable to be tested
   - identify other variables that might be tested at another time
   - identify all controls that are necessary.
4. Select the apparatus and supplies that will be used.
5. Using words/diagrams, describe sequential procedures for performing the experiment.
6. Identify appropriate procedures for recording/communicating data that is gathered.

At times, students may be given procedures for the experiments they are to perform. Before performing these experiments, provide opportunity for students to:

- understand the "thinking" behind the investigation
- consider alternative designs/procedures that might also be effective in answering the question or solving the problem.

Additional suggestions for designing an investigation are provided at the end of this section in:

- Resource 1: Writing a Lab Report
- Resource 2: A Sample Lab Report.

GATHERING DATA

Observing is in some ways the most fundamental skill to science and it is usually the first skill that the student develops to a relatively high level of proficiency. In some ways younger students may be better observers than we adults, as they generally are more ready to accept a wide range of sensory input as worthy of their attention. Nevertheless, the skill is very much subject to development and improvement. One of the principal means by which the student improves skill is by developing the ability to focus thought and attention. Rather than relying on random observations of events, the student begins to recognize patterns of events and conceptualizes observations in terms of these patterns. The student also learns to quantify observations, or in effect, to measure. Measurement skills develop mainly with practice.

The recording of observations and measurements has been included here as a major aspect of this skill. Initially the recording may be the listing of observations in a relatively unstructured way. With practise, the student learns to describe observations in the form of a sequenced narrative of actions and events. At a further level of sophistication the observations may be abstracted from the procedures and described in analytical or point form. At the most advanced level, the student is able to select an appropriate procedure for recording observations where the format is chosen on the basis of clarity rather than conformity to a rigid pattern.

Skills in drawing pictures and diagrams are also part of the data gathering phase. Younger students are generally very ready to use pictorial representations to convey meanings that they have gleaned from their experiences. Initially the drawings may be more impressionistic than precise, with obvious shortcomings in the way relationships between elements have been treated and with obvious inaccuracies in proportion. The drawings nevertheless serve as a basis for the student to express and summarize experiences. As the student advances in skill (which will happen naturally given opportunities to practice), ability to show relationships and proportions gradually improves. At some point the formal skills of diagraming can be introduced, with considerable spin-off benefits to the student's interest and ability to examine objects critically.[1]

Provide abundant opportunities for students to make both qualitative and quantitative observations through direct use of the senses, as well as through the use of specialized observation tools (e.g., microscopes, thermometers, balance scales). Attribute guides are useful in establishing a structure for making observations, and provide an outline that students can follow in accurately describing their observations. In preparing an attribute guide, select attributes that are appropriate to the nature of the observations being made.

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1. Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, p. 19-20, 1983.

CLARIFICATION/EXAMPLE

An Attribute Guide for Describing an Object[1]

Object to be described: _____

Colour:

Shape:

Size (e.g., height, width, thickness):

Weight:

Texture:

Temperature:

State of Motion (e.g., speed, evenness, relationship to other things):

Aroma:

Taste:

Measuring is the process of determining the dimensions/quantity of an object or event using standard units, numbers and spatial relationships. Scientific investigations should provide opportunity for students to:

- make accurate measurements using metric units of length, capacity, mass, temperature and time
- develop skill in estimating by making comparisons to a known standard
- combine familiar units of measure into other measurable dimensions (e.g., density, pressure, velocity)
- interpret the calibrations on measuring instruments used in the laboratory (e.g., beakers, thermometers, spring scales)
- select units and tools of measurement that are appropriate to the task performed
- recognize the approximate nature of measurement and evaluate the precision/accuracy of the measurements they make
- design/construct simple measuring instruments that might be used in particular applications.

Teachers are encouraged to familiarize themselves with the strategies outlined for measurement in the mathematics program, and to use these strategies when applying related skills in the science program.

Additional suggestions for developing student ability to gather and describe scientific data are provided in:

- Resource 3: Observing and Describing
- Resource 4: An Evaluation Guide for Observations.

1. Adapted from *SPELT: A Strategies Programme for Effective Learning and Thinking Inservice Edition*, SPELT International Ltd., p. 102. Copyright 1987 by R. Mulcahy, K. Marfo, D. Peat and J. Andrews. Reprinted by permission.

PROCESSING DATA

Processing data includes all those manipulations that are performed with data in order to make interpretations. Classifying is included as it is seen as a skill that leads to data interpretation. Classifying skill is also closely related to observation in that classification may be based on the observation of similarities and differences. As the student advances in classification skill, many classification decisions that were previously a matter of conscious deliberation come to be made automatically as a part of observation. Thus the distinction between classification, observation and interpretation may at times be blurred. Nevertheless, there appears to be a progression of classification skill from the use of simple category systems to the use of multiple category systems. There is also a progression in the conceptual level of the characteristics used as elements in the classification system.

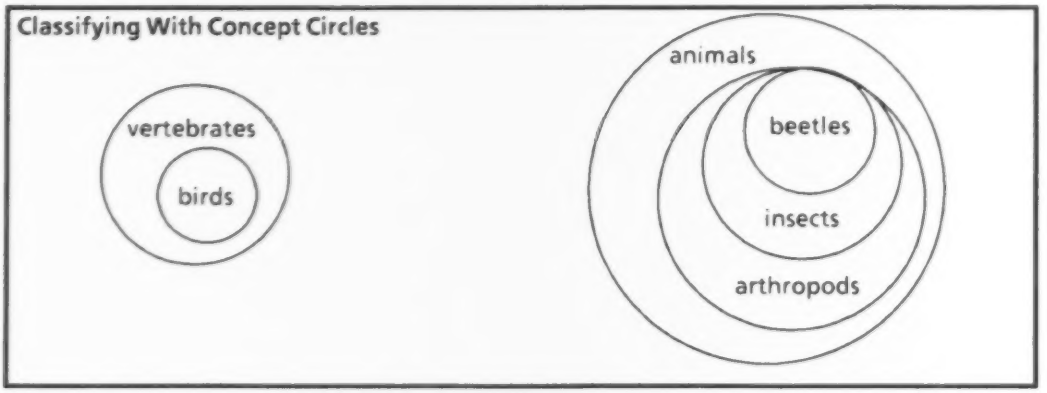
Other skills in this area are those which allow the student to obtain meaning from collections of data, where the meaning may not be evident in isolated observations or measurements. Skills to be developed are largely mathematical, but the development of skills of presentation and layout of data are also significant.[1]

One of the first steps in processing data involves organizing "rough" data into more compact and meaningful forms. Provide opportunity for students to organize the data they collect by:

- ordering objects/events according to observable properties
- making qualitative and quantitative comparisons of objects/events
- classifying objects/events on the basis of observable similarities and differences
- performing simple calculations.

When classifying, assist students to recognize similarities, differences and interrelationships among the objects/concepts/events being examined by using simple diagrammatic representations (e.g., concept circles, concept maps).

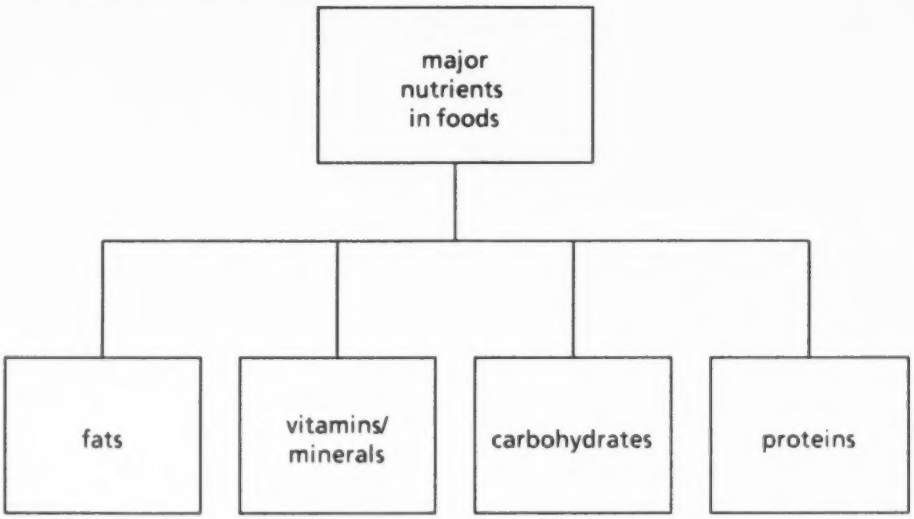
CLARIFICATION/EXAMPLE



1. Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, p. 20, 1983.

CLARIFICATION/EXAMPLE

Classifying With a Concept Map



When presenting data, encourage students to illustrate the information they have collected in an organized and systematic manner, thus enabling anyone to understand its significance. Presentation methods should be chosen that are appropriate to the nature of the investigation and information collected. Students should gain experience in presenting data through the use of:

- oral reports/written reports that follow established guidelines
- sketches/pictures/diagrams
- simple tables/charts/graphs.

As students display their data, it may become apparent that there are recognizable patterns or trends in the data collected. Encourage students to identify these patterns or trends, and to make inferences and predictions that are based upon the patterns they observe.

REVIEWING AND APPLYING RESULTS

INTERPRETING DATA

> The student must give meaning to the observations that have been made by interpreting data. A first stage of interpreting data is inferring, a step in which the student makes a judgement about the evidence obtained in relation to original ideas or proposals. Inferring means making a judgment about a proposed relationship between objects, events, properties and/or living things. At an early level, the student may tend to make a categorical judgment, often inaccurate, on the basis of very little evidence. As skill level advances, the student will likely require much more evidence before making an inference. The inferences made by the more skilled student will likely be expressed in language that is more tentative and more contextual than for a less skilled student. There will be fewer statements of the kind that begins "This proves ..." and more statements of the kind "The data indicates that ...".
>
> The conceptualization of inferred relationships is also included as part of this skill area. This "mental modelling" may take a variety of forms. It may involve the use of some familiar physical system as a model or metaphor for another; it may use some type of spatial model as "a picture" of what the data has shown; it might also be in the form of a mathematical model. As skill in formulating models develops, the student is increasingly able to generate models characterized by a high level of abstraction.[1]

Students should have the opportunity to examine data and formulate their own interpretations before "answers are given". Emphasis should be placed on formulating an explanation rather than the explanation. The process of interpreting data will require students to:

- generalize data by inferring relationships
- distinguish between inference and observation
- develop appropriate explanations/theories/models based on data that is gathered
- evaluate the hypothesis in terms of the existing data.

Provide opportunities for students to gain experience in identifying cause and effect relationships in familiar natural events. Students should realize that there may be more than one cause for certain events. Encourage students to identify as many causes as possible for a given problem. Questions like "What might happen if ...?" and "How does ... apply to ...?" will require students to consider cause and effect relationships and apply these to related situations.

Physical and mental models often provide a useful method of describing unfamiliar phenomena in terms of something that is familiar. Physical models are particularly worthwhile in aiding the student's comprehension of difficult concepts. Types of models used by students may include:

- a picture of an eroded area in the environment
- a diagram of the life cycle of an insect
- a physical model of an electric circuit
- a mental model of an atom.

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1. Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, p. 21, 1983.

In order to evaluate an hypothesis, students must consider the "fit" of the data they collect with the original hypothesis. On the basis of evidence collected, students will decide to confirm or reject their hypothesis. It may be necessary to modify or restate the hypothesis, and therefore undertake further investigation. Encourage students to relate knowledge gained from their interpretation of data to related situations.

EVALUATING THE PROCESS

After completing an investigation, provide opportunity for students to examine critically the procedures/thought processes they have used, and to compare their views with those of other students. Through the use of appropriate questioning techniques, the teacher can encourage students to:

- consider the adequacy of the data in supporting inferences that were made
- distinguish between reasonable inferences and unsupported guesses
- identify possible sources of error in the data collected
- identify intervening/uncontrolled variables that may have affected data collection and results
- recognize limits to interpretations that are based on sample size.

IDENTIFYING FURTHER INVESTIGATIONS

Further investigations are often identified as a result of experiments that are performed. Additional investigations may serve to:

- increase the level of confidence in the inferences/explanations that were made
- test the range of applicability of the explanation
- study the effect of different variables/conditions
- examine discrepant events
- solve new problems that have been identified as a result of experimentation.

As time permits, provide opportunities for students to undertake further investigations. These investigations may take the form of:

- demonstrations/experiments
- projects for a science fair
- field trips
- interviews/class visitors.

SUGGESTIONS FOR USING THE INQUIRY MODEL

The inquiry process has been integrated throughout the curriculum. Themes developed in this manual provide opportunities for students to use the skills of inquiry within meaningful contexts. Students should recognize that the processes and skills of inquiry are "lifetime tools", and when chosen according to purpose and need, are useful in a variety of real life situations.

The following guidelines may be useful in helping students to plan and perform investigations of their own:

- Share the model for inquiry with all students. The model provides structure to the overall process, as well as specific strategies/skills that might be used at each stage of the process. Familiarity with the model will increase the students' repertoire of strategies that can be utilized in performing an investigation.
- Encourage students to be creative and experimental in their approach to investigations. While useful in the structure it provides, the model for inquiry should not be interpreted as consisting of fixed stage and strategies. Its use will depend on individual problems and individual students.
- Ensure that investigations do not become tedious or unrealistically complex. Data related to the phenomena investigated must be readily available, and should be relevant to student interest and experience.
- Foster the development of attitudes and behaviours that promote student thinking and ability to monitor progress through the inquiry process:
  - open-mindedness in considering alternative ideas and interpretations
  - concern for accuracy and evidence
  - honesty and completeness in reporting and evaluating evidence
  - critical mindedness in evaluating inferences and conclusions
  - sub-vocal rehearsal/self-talk (e.g., "Where was I?", "Am I done with this?", "What comes next?").
- Relate the inquiry process to other thought processes used by students. Models for problem solving and decision making are provided in "The Relationship Between Science Technology" and "The Role of Science and Technology in Society" sections of this guide. Encourage students to recognize how the models for inquiry, problem solving and decision making parallel each other in the structure they provide for thinking.

When planning laboratory investigations, provide variation in student activities so as to ensure greater interest and participation. Plan activities that:

- require formal laboratory write-ups, and others that are short, involving no formal write-up
- involve individual work, and others that involve group work
- focus on the development of only one science process, and others that involve several science processes
- acquaint students with a variety of phenomena through a "work stations" approach.

Although laboratory activities and experiments represent an important part of the inquiry process, they should not become the sole teaching strategy. A successful lesson may often include the use of more than one teaching strategy. Inquiry and problem-solving skills should be developed through activities that involve all of the following strategies to varying degrees:

- questioning
- laboratory activities
- individual and group projects
- class discussions
- teacher modelling/demonstrations
- case studies and debates
- community partnerships
- games and simulations
- technology and the media.

The following sequence of activities may assist teachers in planning investigative lessons that involve a variety of teaching and learning strategies:

- Pose a problem.
- Establish an experimental design aimed at solving the problem.
- Give (or have students gather) data required to solve the problem.
- Have students study and interpret their data. Guide activities through the use of leading questions that focus student attention on relevant aspects of the data.
- Formulate generalizations on the basis of data collected. Use questioning techniques that will facilitate the students' use of personal reasoning skills.
- Have a class discussion on the meaning and limitations of the data, the relationship of the data to other problems, and possible applications to everyday life.
- Use questions that may have arisen to extend learning to new areas.

A SAMPLE LESSON PLAN

Activities suggested in this sample lesson plan represent an instructional sequence that might be used in developing an understanding of scientific inquiry. Although this investigation relates to heat and its effects on familiar materials, similar strategies could be used in developing other concepts in the science program. The sequence of activities that have been suggested would require the use of several class periods, and may need to be modified according to student needs and local circumstances.

OBJECTIVES

- To investigate the effects of heat on familiar materials.
- To recognize everyday applications of the expansion and contraction of materials.

I. UNDERSTANDING THE PROBLEM: GAINING ACCESS TO INFORMATION AND IDEAS

• Facilitate a class discussion. Develop an anticipatory mental set for the problem at hand. Relate the problem to personal experience (e.g., "You have just purchased a jar of relish and are unable to open it. What are some procedures you might use to remove the lid?"). Ask questions and cite examples that relate to the effects of heat on solids, liquids, and gases.	QUESTIONING IDENTIFYING THE PROBLEM
• Discuss the Kinetic Molecular Theory and its use in explaining the behaviour of matter. Make an analogy that illustrates this theory. (e.g., "If one hundred people were placed in a room, it might be crowded but they would fit. If they were asked to do some warm-up exercises, they would need more room. That is, they would expand the need for space.")	OBTAINING INFORMATION
• Gain additional information by reading about heat and its effects on matter.	FORMULATING QUESTIONS
• Ask students to identify instances in their personal life where materials used are affected by heat and temperature. Encourage students to consider related situations/tools/materials encountered in the Practical Arts, at home, and in the natural environment. Identify questions or problems experienced by students in these situations (e.g., removing a radiator cap, inflating a bicycle tire).	DEFINING PROBLEMS

II. DEVELOPING AND CARRYING OUT A PLAN: WORKING WITH INFORMATION AND IDEAS

• Have students formulate hypotheses about their personal experiences with heat and matter.	FORMULATING HYPOTHESES
• Provide opportunity for experimentation with heat and matter in situations involving solids, liquids and gases. Design experiments that will validate hypotheses. Students often find this difficult and may require assistance in designing their experiment. Discuss observations to be made in the experiment, measurements that might be taken in determining change in the materials, and a method for recording data.	PLANNING AND EXPERIMENTING COLLECTING AND PROCESSING DATA
• Students who are unable to design their own experiments should be given opportunity to pursue investigations and procedures that are teacher directed.	

III. REVIEWING AND APPLYING RESULTS: DRAWING CONCLUSIONS AND COMMUNICATING RESULTS

• Discuss and evaluate the hypotheses made after considering outcomes of student investigation. Were predictions correct? Provide opportunity for students to communicate their inferences verbally, in written form, or through models and diagrams.	EVALUATING MAKING INFERENCES COMMUNICATING
• Discuss the beneficial and detrimental effects of expansion and contraction (e.g., produces soil out of rock, but also causes deterioration of sidewalks).	IDENTIFYING CAUSE AND EFFECT
• Through brainstorming, identify a number of technologies that apply principles of expansion and contraction. Examine technologies used by students at home and in the Practical Arts (e.g., internal combustion engine, thermometers, food preservation).	APPLYING INFERENCES
• Discuss positive and negative effects of these technologies on our lives. Should any of these technologies be rejected by society because of harmful effects on man or environment?	MAKING DECISIONS
• Identify some present needs of man/society that might be satisfied by new technologies that apply principles of expansion and contraction. Challenge students to devise such a technology.	
• Apply related concepts to other areas in the science program (e.g., electrical-thermal systems).	

RESOURCE 1: WRITING A LAB REPORT

You have probably written lab reports in the past. A report is often a brief summary of an event. In the case of a scientific report, the event is usually staged, or created in a controlled environment and called an experiment.

All experiments start with a guess, or as the scientist calls it, a hypothesis. The hypothesis determines what investigation is carried out because it contains the question which must be answered by the experiment.

The following headings suggest one way to structure a lab report.

Title A few words indicating the nature of the investigation.

Object A sentence or two that describes what the experimenter wishes to find out.

Apparatus A list of materials used. Apparatus can be used after the investigation.

Supplies A further list of materials used. Supplies, unlike apparatus, are consumed during the experiment.

Procedure The steps taken to carry out the investigation. It is customary to number the steps in the sequence in which they should be carried out. Use the present tense.

Observations The findings of your investigation. Observations may be qualitative or quantitative. Quantitative observations, also called data, involve numbers and are often collected in tables, charts, or graphs. A sample quantitative observation would be, "The solution boils at 108° C".

Qualitative observations do not involve numbers and may be written in either sequence or paragraph form, using the past tense. A sample qualitative observation might be, "A red-brown gas escaped".

Conclusions The answer to the question raised in the **object** section. It is based on your observations and data collected during the investigation and is usually written in the present tense. It will either prove or disprove the hypothesis.

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RESOURCE 2: A SAMPLE LAB REPORT

THE EFFECT OF DISSOLVED SALT ON THE BOILING POINT OF WATER

Object To determine the effect of sodium chloride (NaCl) on the boiling point of water.

Apparatus 500 mL beaker, support stand, ring clamp, wire gauze, bunsen burner, flint striker, thermometer, triple beam balance, 500 mL graduated cylinder, watch with a second hand, stirring rod, beaker tongs, or oven mitts.

Supplies Distilled water, filter paper, NaCl.

Procedure

Part A: Control

1. Measure 300 mL of distilled water in a graduated cylinder. Pour the water into the beaker.
2. Attach the ring clamp to the support stand at a height of about 20 cm. Place the wire gauze on the ring clamp.
   Safety Note: Be certain to clear the bench area of any paper, books, or other inflammable materials.
3. Set up a bunsen burner and light it before placing it beneath the ring clamp. Now adjust the height of the flame and the height of the ring clamp so that the tip of the blue inner flame is about 1 cm from the lower surface of the wire gauze. Finally, set the burner under the gauze.
4. Record the initial temperature of the water to the nearest degree.
5. Place the beaker on the wire gauze and record the temperature every two minutes until a constant temperature is obtained for at least three consecutive readings.
   Safety Note: Do not stir the solution with the thermometer because repeated tapping of the tip against the wall of the beaker may cause the thermometer to break. Use a stirring rod.
6. Using oven mitts or beaker tongs, remove the beaker from the stand and place it on a heat resistant pad. Empty the beaker and let it cool to room temperature before starting Part B.

Part B: Salt at 1 g/100 mL

1. Weigh 3 g of NaCl on a piece of filter paper.
2. Measure 300 mL of distilled water and pour it into the beaker.
3. Dissolve the 3 g salt in the water by stirring.
4. Record the initial water temperature.
5. If necessary, adjust the height of the heating apparatus as in step 3 of Part A.
6. Place the solution on the wire gauze. As before, record the temperature of the solution every two minutes until a constant temperature is obtained for at least three consecutive readings.
7. Remove the beaker from the stand using tongs or mitts. Empty the solution. Rinse and dry the beaker before starting Part C.

Part C: Salt at 2 g/100 mL

1. Weigh 6 g of NaCl on a piece of filter paper.
2. Repeat steps two to seven in Part B using 6 g instead of 3 g of salt.

RESOURCE 2: A SAMPLE LAB REPORT (continued)

Observations

1. Boiling appeared to be the same in all three experimental solutions.
2. The solutions appeared to heat at approximately the same rate.
3. The table below illustrates the temperatures recorded while heating the three solutions.

DATA TABLE

Time in Minutes	Temperature (° C)		
	300 mL water	300 mL water and 3 g NaCl	300 mL water and 6 g NaCl
0	20	21	20
2	25	27	26
4	38	40	40
6	50	49	52
8	70	69	71
10	93	88	90
12	100	102	103
14	101	102	103
16	100	102	103

Conclusions

1. Dissolving NaCl in water tends to increase the boiling point.
2. It appears that the higher the concentration of NaCl, the higher the boiling point. However, the experiment should be repeated with several solutions of higher concentration before this inference can be confirmed.

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RESOURCE 3: OBSERVING AND DESCRIBING

Descriptive writing records observations. You must be accurate and precise without using unnecessary words. Moreover, the description must state only what is observed, never what is suspected, inferred, or believed. Eliminating these interfering opinions is often difficult but in time you will become quite conscious of them.

There are two basic types of observations.

- **Qualitative** observations describe the general characteristics of an object. An example is "The automobile is a blue sedan."

- **Quantitative** observations involve measurement of an object. An example is "The automobile was 2.5 m long."

Scientists must be precise, and attempt to gather as many quantitative observations as possible. This is why people often say that "mathematics is the language of science".

Observations, sometimes reported in paragraphs, are most often written as complete sentences in lists. If a series of quantitative observations are collected they are usually put in a chart so that the reader can get an overview of the data at a glance. The chart may also be converted to a line graph or a bar graph to illustrate the pattern indicated by the data.

ASSIGNMENT 1

Your teacher will give you and your partner an everyday object such as a candle or a paper cup. Your task is to write the best series of observations to describe the object. Keep your qualitative and quantitative observations separate. It should be possible for you to list at least 50 or 60 observations in 30 minutes.

ASSIGNMENT 2

Working as an individual, you will be assigned something for observation. As you did in the previous activity, record as many qualitative and quantitative observations as possible on separate lists.

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RESOURCE 4: AN EVALUATION GUIDE FOR OBSERVATIONS

Your assignments in Resource 4 can be marked using the list of criteria below. Try answering the questions and marking your assignments yourself; then revise your observations to obtain a better mark.

	Possible Score	My Score
1. Did you list qualitative observations and quantitative observations? Have you presented them separately?	4	
2. Is each observation presented in a full sentence? If you read each one separately, can you tell what it means without referring to the others?	4	
3. Are any of your statements not observations? Deduct one mark each time you find: • an **opinion** • an **inference** • a **belief**, or • a **suspicion**. Check separately for each of them.		
4. Did you collect any quantitative data that can be tabulated? Have you presented these in a data table?		
Be sure your table has:		
• a title	2	
• a heading for each column, and	3	
• a unit expressed for each.	2	
Total:	15	

Scale Point

One The lists offer little accurate description. The description obtains 0 to 9 points.

Two Accurate description has been provided, but either the format of the presentation is weak or a great deal of irrelevant material – opinions, inferences, beliefs, suspicions – has been included. The description obtains 10 to 12 points.

Three Accurate description has been effectively presented. Data are appropriately tabulated. The description obtains 13 to 15 points.

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THE RELATIONSHIP BETWEEN SCIENCE AND TECHNOLOGY

Science and technology combine to affect almost every aspect of our lives. The science program must provide for an understanding of what science and technology are, and how they interact in producing familiar products and processes. Students should become familiar with the technological problem-solving process, and gain experience in using this process in solving problems of a practical nature.

Learning activities used throughout the science program will enable students to recognize:

- that technology is concerned with the solution of practical problems
- that significant aspects of the technological problem-solving process include:
  - approaching a problem in a planned way
  - developing a practical design as a means to support, modify or reject alternative ideas for solving a problem
  - creativity and inventiveness in developing solutions
  - critical thinking in the evaluation of potential solutions
- basic scientific principles associated with the operation of familiar technologies
- that science can be used to advance technology and that technology can be used to advance science
- various technologies as they are used in practical situations.

Problem-solving activities should be selected on the basis of the opportunities they provide for students to:

- recognize that technological processes/devices are developed to meet the needs of individuals and society
- develop confidence in personal ability to solve practical problems
- recognize alternative strategies for solving problems
- develop and use psychomotor skills
- use critical and creative thinking skills
- appreciate efficiency and design in technological systems.

A variety of teaching and learning strategies that may be used to illustrate interactions between science and technology and their influence on our daily lives have been included in this section of the manual. The content supports active involvement in solving technological problems, and includes:

- Understanding Science and Technology
  - Distinguishing Between Science and Technology
  - Interactions Between Science and Technology
- A Model for Technological Problem Solving
- Suggestions for Using the Problem-Solving Model.

UNDERSTANDING SCIENCE AND TECHNOLOGY

DISTINGUISHING BETWEEN SCIENCE AND TECHNOLOGY

Science is the process of answering questions that arise from curiosity about natural phenomena. Science orders our knowledge of the natural world, and allows us to predict the outcome of natural events. Technology, on the other hand, is the process of using scientific knowledge and other resources to develop products and processes. When we engage in technology, we attempt to solve practical problems in order to meet the needs of an individual or society. An engineering approach rather than a scientific approach is used in technology.

CLARIFICATION/EXAMPLE

Examples of Science Include:

- finding out how something "works"
- investigating the cause of acid rain
- classifying plants on the basis of observable characteristics.

Examples of Technology Include:

- the development of vaccines to control disease
- the development of consumer products (e.g., home appliances, canned foods, automobiles)
- the development of a new computer game.

Instructional activities should provide opportunities for students to distinguish between familiar situations involving science and those involving technology, and to recognize how technology influences various aspects of their everyday lives (e.g., food, shelter, clothing, transportation, health). The chart that follows compares the scientific and technological processes, and may be useful in structuring related activities.

	SCIENCE	TECHNOLOGY
TYPE OF ACTIVITY:	Theoretical	Practical
PROBLEMS ARISE FROM:	Curiosity about events and phenomena in the natural world	Wants/needs of individuals and society to accomplish specific tasks
RELATED QUESTIONS:	• Why does ... ? • How do we know that ... ?	• What can we do to ... ? • Will it work?
STRATEGY:	Scientific Inquiry	Technological Problem Solving
OUTCOMES/ SOLUTIONS:	Knowledge about natural phenomena	Products and processes designed to achieve intended purposes
EXAMPLES:	Why does my coffee cool so quickly? (Heat energy is transferred by conduction, convection and radiation.)	How can I keep my coffee hot? (A thermos is designed and constructed to keep liquids hot for periods of time.)

Sample activities that will help students to distinguish between science and technology are provided at the end of this section in:

- Resource 1: How Does Technology Affect Our Everyday Lives?
- Resource 2: How Frequently Do I Make Choices About Technology?
- Resource 3: How Are Science and Technology Different?
- Resource 4: What Do Engineers and Scientists Do?.

INTERACTIONS BETWEEN SCIENCE AND TECHNOLOGY

Science and technology interact and advance one another. Scientific principles frequently contribute to the development of technological devices and processes. These technologies, in turn, may identify significant questions that lead to the discovery of other scientific principles. Sometimes a technological device or process is developed without knowledge of the scientific principle behind it. This technology may then lead to the discovery of new scientific principles.

SCIENCE ⟷ TECHNOLOGY

Teachers should emphasize interactions between science and technology at appropriate points within each theme of the science program. By asking relevant scientific and technological questions, students can be encouraged to make logical connections between science and technology, and to recognize:

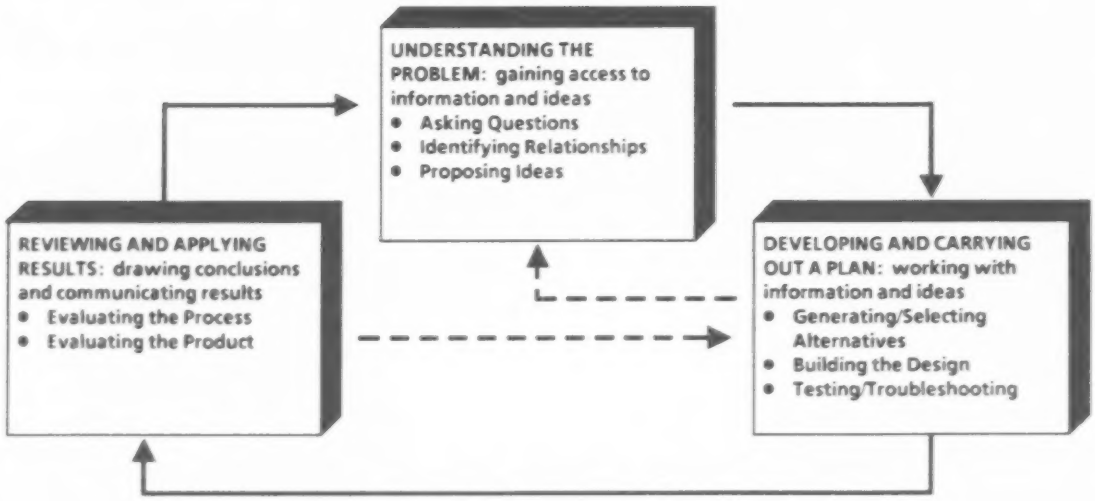
- the scientific principles upon which familiar technologies are based
- technological products/processes that are based upon the scientific principles being investigated.

A sample activity that will help students to develop an understanding of how science and technology interact is provided at the end of this section in Resource 5: What is the Scientific Basis for Technology?

A MODEL FOR TECHNOLOGICAL PROBLEM SOLVING

Students should have opportunities to apply scientific concepts/principles in solving practical problems of a technological nature. Critical to the development of skills in technological problem-solving is the attitude with which students approach a problem. People are often uneasy and hesitant to involve themselves in situations where procedures are not easily determined and solutions are not evident. Appropriate attitudes must be nurtured through an atmosphere that provides encouragement, flexibility and acceptance. Discussion and activity should foster student interest and desire to solve practical problems. Students must be persuaded to take risks that are associated with inventing new solutions to practical problems, and to recognize the importance of planning and testing alternative ideas in designing a product or process that serves an intended purpose.

Students will be supported in their understanding of the problem-solving process when problems are selected that relate to personal experience, interest or need. Particular emphasis should be given to problems that incorporate hands-on activities in their solution. The model that follows suggests an overall process for solving problems. It provides a starting point and some ways to organize efforts.


UNDERSTANDING THE PROBLEM: gaining access to information and ideas
• Asking Questions
• Identifying Relationships
• Proposing Ideas
DEVELOPING AND CARRYING OUT A PLAN: working with information and ideas
• Generating/Selecting Alternatives
• Building the Design
• Testing/Troubleshooting
REVIEWING AND APPLYING RESULTS: drawing conclusions and communicating results
• Evaluating the Process
• Evaluating the Product

Specific actions identified at each stage of the problem-solving process represent possible strategies that might be used in solving a problem. Students may not always use each stage of the process, and will select only those actions that are appropriate to purpose and ability. Students should, however, recognize problem solving as a series of interrelated actions that lead to a solution or outcome.

By bringing thought processes to the metacognitive level (i.e., helping students to become aware of the thinking skills and thought processes that they and others use), students will be better able consciously to select and use those strategies and skills that are appropriate to the situations they encounter. Research strongly supports the teaching practice of:

- modelling (talking through) the processes and skills that are appropriate to solving a particular type of problem
- discussing the processes and skills that the student is presently in the habit of using (i.e., raising the level of metacognitive awareness)
- encouraging students to develop additional strategies that will structure and support the thought process.

The model for solving technological problems should be explicitly presented to students as an overall process and used as a teaching and learning model in problem-solving situations. The chart that follows suggests student activities that may be appropriate at each stage of problem solving represented in the model.

UNDERSTANDING THE PROBLEM	• identifying problems • identifying sub-problems • asking questions • identifying relationships
DEVELOPING AND CARRYING OUT A PLAN	• identifying alternative approaches/designs for solving the problem • developing/interpreting simple diagrams that illustrate problem-solving designs • developing/interpreting flow charts that represent approaches to problem solving • constructing prototypes • testing/troubleshooting • carrying out a problem-solving approach
REVIEWING AND APPLYING RESULTS	• evaluating a design • evaluating a problem-solving approach • evaluating a prototype • proposing improvements

Activities that develop an understanding of the technological problem-solving process, and offer opportunity for "hands-on" experience in solving practical problems are provided in:

- Resource 6: How is a Technological Product Developed?
- Resource 7: Can I Make a Better Paper Airplane?

SUGGESTIONS FOR USING THE PROBLEM-SOLVING MODEL

Themes developed in this manual provide opportunities for students to develop and use technological problem-solving skills within meaningful contexts. Through discussion and activity, students should recognize that the processes and skills of problem solving are "lifetime tools", and when chosen according to purpose and need, are useful in a variety of real life situations.

The following guidelines may be useful in helping students to understand and apply the problem-solving model:

- Share the problem-solving model with all students. The model provides structure to the overall process, as well as specific strategies/skills that might be used at each stage of the process. Familiarity with the model will increase the students' repertoire of strategies that can be utilized in solving a problem.
- Encourage students to be creative and experimental in their approach to problem solving. While useful in the structure it provides, the model for problem solving should not be interpreted as consisting of fixed stages and strategies. Its use will depend upon individual problems and individual students.
- Assist students to become aware of the thinking skills and thought processes that are useful in solving problems. Ask questions that encourage students to discover their own answers, and model (talk through) complete thought processes that are used in problem solving.
- Select problems that are relevant in the local community and that relate to the students' personal experience. Gather data related to relevant problems through a variety of methods:
  - direct observation
  - reading/viewing
  - interview/discussion/debate.
- Ensure that problem solving does not become tedious or unrealistically complex. Data related to the problem should be readily available. Remember that technology includes not just the "big things" that are the focus of societal issues, but also the "little things" that people do every day:
  e.g., - how a bicycle or toy is repaired
  - how dishes are stacked for drying
  - how clothes are arranged in a closet or drawer.

  Since these kinds of technologies are most relevant to students, include them in your instruction.
- Provide opportunities for students to learn from each other. Individual students often have knowledge of particular processes/devices, and should be encouraged to share this knowledge with others.
- Research some important contributions made by Canadian scientists and engineers to the field of science and technology:
  - What problem stimulated the scientist/engineer to do the work?
  - What problem-solving strategies were used to find a solution?
  - What is the domestic/international significance of this contribution?
- Arrange for a scientist/engineer from a local university/hospital/research station to visit the class and discuss:
  - the kinds of problems they solve
  - the strategies/skills they use in solving problems.
- Relate the problem-solving process to other thought processes used by students. Models for inquiry and decision making are provided in "The Nature of Science" and "The Role of Science and Technology in Society" sections of this guide. Encourage students to recognize how the models for inquiry, problem solving and decision making parallel each other in the structure they provide for thinking.

The themes identified below provide a logical focus on the interactions of science and technology in solving practical problems. Activities that accompany each theme represent possible approaches to problem solving. Teachers may wish to use these suggestions in combination with other activities considered appropriate to student interest, experience and ability in developing problem-solving skills.

GRADE 8

THEME: USING ENERGY AND MACHINES

- Identifying alternative designs for the construction of a device that makes efficient use of energy.
- Developing/interpreting a simple diagram that illustrates subsystems and component parts within a system.
- Constructing a prototype device that makes efficient use of energy (e.g., a rubber band car).
- Troubleshooting problems with a prototype.
- Proposing improvements in design that lessen frictional losses within a given system.

THEME: GROWING PLANTS

- Identifying problems related to growing plants.
- Identifying alternative approaches to plant propagation.
- Developing/interpreting a flow chart that represents approaches to plant propagation.
- Carrying out alternative approaches to plant propagation.
- Evaluating alternative approaches to plant propagation.

GRADE 9

THEME: USING CHEMICAL PRODUCTS

- Identifying problems related to the corrosion of materials.
- Identifying alternative approaches to reducing corrosion of materials.
- Developing/interpreting a flow chart to show an approach to reducing corrosion.
- Carrying out an approach to reduce corrosion.

THEME: ELECTRICAL SYSTEMS IN THE HOME

- Identifying alternative designs for constructing a simple electronic device (e.g., burglar alarm, thermostatically controlled switch).
- Developing/interpreting a simple diagram that illustrates basic components of an electromagnetic device.
- Developing/interpreting simple wiring diagrams.
- Evaluating alternative designs for a home circuit.

RESOURCE 1: HOW DOES TECHNOLOGY AFFECT OUR EVERYDAY LIVES?

PURPOSE

To recognize how technology affects our daily activities.

PROCEDURE

1. Make a list of the products of technology that you encounter:

   - on the way to school in the morning
   - during the school day
   - during after-school activities
   - at home in the evening.

2. Classify your products according to human needs such as:

   - water
   - food
   - shelter
   - transportation.
   - communication
   - health
   - recreation

RESULTS

A typical list of technological products might look like the following:

Group	Products
water	running water (especially hot water for bathing)
food	frozen and canned foods, snacks, milk and ice cream, fresh vegetables, toaster, stove, refrigerator, microwave oven
shelter	furnace, house, electric blanket
transportation	cars, buses, subways, trains, roads, traffic lights
communication	radio, books, television, pens and pencils, paper, telephone, movies, micro-computer
health	toothpaste, vitamins
recreation	sports equipment, stereo systems, games

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RESOURCE 2: HOW FREQUENTLY DO I MAKE CHOICES ABOUT TECHNOLOGY?

PURPOSE

To illustrate the many technological processes or products from which a person chooses in a typical day.

PROCEDURE

1. On a chart like the one shown, make a list of the activities you engage in over the course of a day. Describe the choices of technology available to you in doing each activity, and your actual choice.

Activity	Choices Available	Your Choice
brushing teeth	manual toothbrush/ electrical toothbrush	
drying hair	hair dryer/towel and air	

2. Answer the following questions;

   a. How many technological devices do you use in a day?

   b. How many activities offer no choice of alternative technological devices? One choice? Two choices? Three of more choices? Make a bar graph of this data.

   c. Would you say that technology offers you increased choices in your life? Why or why not?

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RESOURCE 3: HOW ARE SCIENCE AND TECHNOLOGY DIFFERENT?

PURPOSE

To distinguish between science and technology.

MATERIALS

Collect pictures and/or descriptions of people engaged in science or technology. Suggested pairs of pictures showing people engaged in science and technology include:

SCIENCE	TECHNOLOGY
Galileo observing motion of objects rolling down an inclined plane.	Young people coasting down hill in a soap box racer.
A chemist heating a test tube over a bunsen burner.	Someone using a stove to heat food.
A microbiologist looking through a microscope.	A doctor or nurse immunizing a patient against disease.

PROCEDURE

1. Show pictures or read descriptions to students. Are the people pictured or described engaged in science or technology? Use student responses to discuss the relationship and difference between science and technology.

   Use the pictures/descriptions to make a bulletin board display. Classify each situation as "science" or "technology".

2. Ask students to collect additional pictures or write their own descriptions of people engaged in science or technology. Encourage students to share these with the class and add them to the bulletin board display.

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RESOURCE 4: WHAT DO ENGINEERS AND SCIENTISTS DO?

PURPOSE

To provide concrete examples of how an engineer and a scientist solve problems.

PROCEDURE

A. Invite one or two engineers to speak to the class about the work they do. It is helpful if the engineers are working on a project that is of interest to students, such as a new product students might use. (An engineer can be located through local industry or a student's parent may be an engineer.)

B. Provide the engineers with information on what the class is studying, including the problem-solving model. Remind the engineers of the students' grade level, and ask them to use a problem they are working on to illustrate the problem-solving model. Encourage the engineers to bring some physical representations of the problem, such as the design and the prototype.

C. Several days before the class visit, ask students to make a list of questions they would like to ask the engineers. Appoint one or two students to act as hosts/hostesses and to introduce the guest speakers.

D. Repeat A-C by inviting one or two scientists to speak to the class about how they use inquiry and problem solving.

E. Discuss the similarities and differences between engineers and scientists. Are their work roles totally separate? Is there overlap between what they do?

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RESOURCE 5: WHAT IS THE SCIENTIFIC BASIS FOR TECHNOLOGY?

PURPOSE

To identify the scientific concepts that are associated with technological devices or processes.

PROCEDURE

Consider your list of technologies in Resource 1 or the list below. Discuss the scientific concept that each technological device or process is based upon.

Device or Process:

1. Pasteurization
2. Ball bearing
3. Barometer
4. Thermometer
5. Thermostat
6. Electric meter
7. Microscope
8. Solar Cell
9. Christmas tree lights
10. Hot air balloon

RESULTS

Scientific principles that govern the operation of the technologies listed above are provided below. Other lists can easily be made from the content of individual themes in the science program.

1. Heat kills bacteria.
2. Friction can be reduced by decreasing the area of surface contact.
3. The pressure of columns of different static fluids at the same level must be the same.
4. Most substances expand when heated.
5. Different substances expand by different amounts when heated.
6. Magnets exert a force on electric current.
7. Lenses refract light to focus images.
8. Electrons in solids can be excited to higher energy levels when they absorb light.
9. If enough heat is generated by passing an electric current through a filament, light is given off.
10. Archimedes' principle.

ALTERNATIVE ACTIVITY

Describe a scientific concept/principle and ask students to identify familiar technological devices/processes that demonstrate use of the principle.

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RESOURCE 6: HOW IS A TECHNOLOGICAL PRODUCT DEVELOPED?

PURPOSE

To illustrate that fairly uniform steps are followed in developing a technological product.

MATERIALS

Library reference books and magazines.

PROCEDURE

A. Divide the class into groups of three students each. Ask each group to choose one of the following technological products:

- airplane
- automobile
- bicycle
- electric motor
- radio
- television
- telephone
- light bulb
- microcomputer
- stereo.

B. Using library resources, have each group research the development of its chosen product and answer the following questions.

1. What need was the product designed to fulfil?
2. How did the idea for the product first come into the mind of the inventor(s)?
3. What kind of research was done before the product was developed?
4. What were the main features of the product's design?
5. Describe the prototype or initial form of the product that was constructed.
6. How was the prototype tested?
7. In what ways was the prototype modified before the product was mass produced?

C. Ask each group to report its findings to the class and respond to other students' questions.

RESULTS

Students should realize that most technological products are developed using methods that are quite fundamental to problem solving.

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RESOURCE 7: CAN I MAKE A BETTER PAPER AIRPLANE?

PURPOSE

To develop and use technological problem-solving skills.

MATERIALS

paper
reference books
safety glasses

PROCEDURE

1. Working in groups of three to four, use problem-solving skills to design and produce paper airplanes.

   a. **Identify the need or problem:**
   What is the problem you want to solve, or need you want to meet? Examples might include:

   - Is there an accurate way to get waste paper into a waste basket?
   - How can we make a device that will stay in the air the longest?
   - What device will fly the longest distance?

   b. **Develop a plan or idea:**
   Discuss ways to solve your problems (e.g., getting paper to a waste basket by folding it into a shape like an airplane is a possible idea).

   c. **Research the plan or idea:**
   What additional information do you need? (e.g., What type of paper is best? What plans have others developed?)

   d. **Develop a design:**
   Based on the principles of flight, design an airplane to solve your problem or meet your need.

   e. **Build a prototype:**
   Build the airplane from your design.

   f. **Test the prototype:**
   Decide what tests you will use on your prototype. Carry out the tests and keep accurate records. (e.g., How many times did the airplane go into the waste basket?)

   g. **Evaluate the prototype:**
   How well did the prototype perform? (e.g., Did it consistently hit the waste basket?) Can its performance be improved by redesign? If so, redesign it.

h. **Acceptance and production:**
If the prototype is accepted (with or without redesign) it is then ready for production. If the prototype is rejected, you may wish to go back and start again at (b).

2. Answer the following questions:

a. When problem-solving is used in industry and business, who identifies the need or problem? Who evaluates the product?

b. Are consumers ever involved in need identification? In evaluation?

NOTE: At the end of this activity, an airplane-flying contest can be held for each problem identified by students. The contest can be compared to market competition, where planes are examined for their design superiority.

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RESOURCE 8: HOW SHOULD WE ASSESS A TECHNOLOGICAL PROCESS OR DEVICE? (continued)

RESULTS

Indicated in parentheses. Students should begin to realize that it is possible to assess technological processes/devices by the burdens and benefits they create. However, assessment depends on an ability to predict future consequences. We do not always possess this ability. When a decision is made to adopt or reject a particular process/device, there may not be total agreement about that decision.

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RESOURCE 8: HOW SHOULD WE ASSESS A TECHNOLOGICAL PROCESS OR DEVICE?

PURPOSE

To develop a process for assessing a technological process or device.

PROCEDURE

1. Using the chart provided, describe the benefits and burdens placed upon people and the environment when each of the technological processes/devices are put into use in our society.

2. Place an asterisk in front of each technological process/device for which you feel the benefits outweigh the burdens. Be prepared to discuss your reasons.

3. How often did you and your classmates agree that a particular process or device should be (or should have been) adopted?

4. How can people assess whether or not to adopt a technological process/device?

DATA TABLE

Technological Process or Device	Benefit	Burden
nuclear energy	(additional electricity)	(risk of war, radioactive wastes)
mass transportation	(less pollution, less energy used)	(personal inconvenience, large cost)
robotics	(modernized, efficient industry)	(loss of jobs)
drugs	(treat diseases)	(dependence through abuse)
pesticides/insecticides	(increased agricultural yields)	(extinction of helpful species)
product packaging with synthetic materials	(fresher food)	(nonbiodegradable waste in landfills)
computers	(increased ability to process data)	(loss of jobs, health problems from video-display terminals)
space travel	(increased knowledge)	(high financial cost)
life-sustaining devices	(keep people alive)	(how to decide when to use or remove them)
organ transplants	(increased life span)	(cost, decision as to who receives them)
automobiles	(increased mobility)	(increased pollution, deaths)
chemical fertilizers	(increased agricultural yields)	(eutrophication of lakes)
artificial sweeteners	(convenience for diabetics and dieters)	(increased risk of cancer)

RESOURCE 7: WHY ARE SOME INVENTIONS NOT ACCEPTED BY SOCIETY?

PURPOSE

To consider why certain technological designs were never widely accepted.

PROCEDURE

1. Consider the following list of patented inventions:

   - a fake cigarette package that coughs loudly when picked up
   - children's forks and spoons whose handles are made into musical whistles
   - a beauty mask for women to wear at night while sleeping
   - parakeet diapers
   - a firecracker fire alarm
   - a golf ball that sends out a smoke signal when it lands to help locate it
   - a gun whose curved barrel extension allows it to shoot around corners
   - a coffin with a tube for fresh air and an alarm
   - an automatic baby-burper
   - a gold trap which, when swallowed, is supposed to catch tapeworms.

2. Discuss why each of the above inventions has not become widely accepted.

3. Suggest an invention that might be useful and describe it to the class.

4. Poll the class to determine which student inventions are most popular. Which appear to be most useful?

RESULTS

Each week, thousands of inventions are registered. Millions of patents have been issued since 1790. Clearly, many of these innovations were thought to be more important by their inventors than by the society which neglected to use them.

(Patented inventions were selected from Patents Ridiculous and Sublime by Stacy, V. Jones, Quadrangle/The New York Times Book, Co., 1973.)

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RESOURCE 6: WILL NO-TILL PLANTING BE ACCEPTED AS A FARMING PRACTICE?

PURPOSE

To show that acceptance of a technological process depends on the attitudes of individuals or societies toward it.

INTRODUCTION

Conventional plowing methods have contributed to the loss of half of the nation's topsoil during this past century, and the loss is growing. Conventional plowing produces "clean" fields and good weed control.

Recently, no-till planting, or planting without turning over the soil, has challenged old methods. The advantages of no-till planting include:

- Wind and water erosion are reduced when the previous season's crops remain in place.
- Less fuel is used in growing crops because both planting and herbicide application are done in just one trip over the field.
- Decreased evaporation increases the amount of water in the soil that can be used by the crop.
- Winter ground cover provides protection to wildlife.

PROCEDURE

1. Interview farmers, conservationists, and environmentalists in your area and report your findings on no-till planting.

   Some sample questions which you might ask include:

   a. Is no-till planting better than conventional methods? Why?

   b. What are the disadvantages, if any, of no-till planting?

   c. Why do some farmers oppose no-till planting?

   d. Should we influence farmers to start no-till planting?

   e. How important is the conservation of topsoil?

   f. Do the benefits from no-till planting outweigh the burden of herbicide dangers?

2. Discuss in class the views of farmers, conservationists, and environmentalists about no-till planting. What are your views? Why are these your views?

3. Conduct a survey among farmers to determine how widely accepted no-till planting has become.

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RESOURCE 5: WHERE ARE THE JOBS AND CAREERS?

PURPOSE

To use newspaper classified sections to see what jobs and careers are available, and what training is necessary for them.

MATERIALS

Classified sections from local and large-city newspapers.

PROCEDURE

1. From the classified sections of the newspapers, cut out ten "Help-Wanted" ads.

2. Describe the training necessary to obtain each of the jobs.

3. As a class, discuss the following questions:

   a. How can an individual obtain the training necessary to obtain or change jobs?
   b. What can students do to prepare for a changing job market?
   c. Which of the jobs or careers interest you most? Why?

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RESOURCE 4: HOW HAVE JOBS AND CAREERS CHANGED IN THE LAST THIRTY YEARS? (continued)

Persons working less than ten years:

- Number of jobs newly created by a technological advance _____ .
- Number of jobs previously performed by someone else _____ .
- Number of jobs using computers _____ .
- Number with changes in jobs expected in the next ten years _____ .

5. Plan a field trip to industries that are utilizing new technological devices or processes. If possible, select a company that has an employee "retraining" program. Observe the work people are doing.

6. Write a brief paragraph describing your observations in question 5.

7. Look at the class data from question 4 and your raw data from questions 1, 2 and 3. Write two or three paragraphs that summarize how science and technology have affected business, industry, career choices, and employment in the last 30 years.

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RESOURCE 4: HOW HAVE JOBS AND CAREERS CHANGED IN THE LAST THIRTY YEARS?

PURPOSE

To investigate changes in business, industry, career choices, and employment brought about by science and technology.

PROCEDURE

1. Interview a retired person and ask the following questions. Record the answers.

   a. What was your first full-time job?
   b. How long did you continue to do that type of work?
   c. If you changed the type of work you did, what was the reason?
   d. How many different types of work did you do?
   e. Of all the types of work you did, how many of those jobs are still available today?
   f. What has replaced the jobs no longer available?

2. Interview someone who has been working in the same job at least ten years and ask the following questions. Record the answers.

   a. What changes have you seen in your job in the past ten years?
   b. Have computers affected your job?
   c. What changes do you expect to see in your job in the next ten years?

3. Interview a person who has been employed full-time for less than ten years and ask the following questions. Record the answers.

   a. Was your job newly created by some technological advance or was it performed by someone else before you?
   b. Do you use computers on your job?
   c. What changes do you expect to see in your job in the next ten years?

4. Tabulate class results.

   Retired persons:

   - Number with same type of job entire life _____.
   - Number with two different types of jobs _____.
   - Number with more than two different types of jobs _____.
   - Total number of types of jobs _____.
   - Number still available today _____.

   Persons working ten years:

   - Number of changes in jobs in the last ten years _____.
   - Number affected by computers _____.
   - Number with changes in jobs expected in the next ten years _____.

RESOURCE 3: HOW DO SCIENCE, TECHNOLOGY AND SOCIETY AFFECT EACH OTHER?

PURPOSE

To show that developments in either science, technology or society also affect the other two areas.

PROCEDURE

Ask your students to suggest situations in which developments in science have affected technology and society and also situations in which attitudes in society have affected science and technology. If they encounter difficulty, you might offer hints from the examples below.

DEVELOPMENTS IN SCIENCE THAT HAVE AFFECTED TECHNOLOGY AND SOCIETY:

SCIENCE	TECHNOLOGY	SOCIETY
laws of motion	space travel	new products, greater knowledge of universe
electricity	electrical appliances	more leisure time
electromagnetic waves	radio and TV	home entertainment
chemistry	synthetic materials	new products
nuclear fission	nuclear reactors	reduced dependence on oil

ATTITUDES IN SOCIETY THAT HAVE AFFECTED SCIENCE AND TECHNOLOGY:

SOCIETY	SCIENCE	TECHNOLOGY
funding of medical research	medical research	new diagnostic techniques
prohibition of genetic engineering laboratories	restricted research	slow technological development

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RESOURCE 2: HOW HAVE OUR CHOICES IN LEISURE ACTIVITIES CHANGED?

PURPOSE

To show that technology has greatly increased the number of ways we can spend our leisure time.

MATERIALS

Reference books.

PROCEDURE

1. Make a list of the ways you can spend your leisure time (e.g., after school, evenings, weekends).
2. Place a check next to the ways which were also available to your parents when they were your age.
3. Place a second check next to the ways which were available to your grandparents when they were your age.
4. Place a third check next to the ways which were available to the earliest settlers in Canada.
5. Place an asterisk in front of the ways which depend on technology.
6. Observe some relationships between the asterisks, check marks and activities in your list.

RESULTS

Student lists may look like the following:

*✓	Television
*✓ ✓	Movies
*	Video games
*✓ ✓ ✓	Visit with friends
*	Watch movies at home on the VCR
*✓ ✓ ✓	Eat
*✓ ✓ ✓	Read
*✓ ✓ ✓	Play games (non-video)

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RESOURCE 1: WHAT WERE THE "GOOD OLD DAYS" REALLY LIKE? (continued)

RESULTS

Students, in comparing the possibilities in 1889 and today, will realize that vast improvements have occurred in transportation, communication, health care, and personal opportunities. However, some may realize that such progress has come at the expense of the environment, national security and the extended family. The key concept is that science and technology invariably change society.

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RESOURCE 1: WHAT WERE THE "GOOD OLD DAYS" REALLY LIKE?

PURPOSE

To illustrate that science and technology have changed society and our lifestyles a great deal in the past century.

MATERIALS

Reference books.

PROCEDURE

1. Work in groups of three. With the help of reference books, your teacher and other adults, answer the following questions:

   a. Using the fastest transportation available, how long would it have taken you to reach Toronto, Ontario in 1889? How long would it take you today?

   b. How quickly would you have been able to contact a relative living in Vancouver, B.C. in 1889? How long would it take today?

   c. What would you have used to go shopping in a town ten kilometres from your home in 1889? What would you use today? How long would a round trip have taken in 1889? How long would it take today?

   d. What might you have done to entertain yourself in 1889? For how many hours per week would you have been engaged in such leisure in 1889?

   e. What might you do to entertain yourself today? For how many hours per week would you engage in such leisure today?

   f. How many years would you have expected to live in 1889? How many years do you expect to live today?

   g. What diseases that might have threatened you in 1889 have been virtually eliminated as threats today?

   h. What careers might you pursue today that were not available to you in 1889?

2. Review and compare group responses to the above questions in class. Summarize your discussion with the following questions:

   a. In what ways have our lives been made better by achievements in technology over the last century?

   b. What good things have been lost through the impact of technology over the past century?

The themes identified below provide a logical focus on the role of science and technology in society. Activities that accompany each theme represent possible approaches to decision making. Teachers may wish to use these suggestions in combination with other activities considered appropriate to student interest, experience and ability in developing decision-making skills.

GRADE 8

THEME: INTERACTING WITH OUR ENVIRONMENT

- Identifying which perspective (e.g., economic, political, scientific) is being used to inform consensus building about an environmental issue.
- Evaluating consumer products in terms of their effect on the environment.
- Gathering information about alternative technologies for monitoring environmental quality.
- Using scientific knowledge to make decisions and take actions that will maintain a healthy environment.
- Evaluating the defensibility of an action affecting environmental quality from several different perspectives (e.g., technological, political, ethical.)

GRADE 9

THEME: MONITORING THE LOCAL ENVIRONMENT

- Identifying the points of view of various groups on environmental issues.
- Identifying which perspective (e.g., economic, political, scientific) is being used to inform consensus building about an environmental issue.
- Evaluating consumer products in terms of their effect on the environment.
- Gathering information about alternative technologies for monitoring environmental quality.
- Using scientific knowledge to make decisions and take actions that will maintain a healthy environment.
- Evaluating the defensibility of an action affecting environmental quality from several different perspectives (e.g., technological, political, ethical).

- Ask questions that will challenge students to use higher-level reasoning skills and to explore ideas they may not have considered. Useful types of questions include:
  - Can you tell me more about ...?
  - What else might happen if ...?
  - If ... then ...?
  - How did you arrive at that conclusion?
  - What made you ask that question?
  - Why do you say that?
  - How did you think of that idea?

- Provide opportunities for students to clarify their ideas and justify the positions they adopt through writing activities. Guidelines for structuring writing activities are provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

- Relate the decision-making process to other thought processes used by students (e.g., scientific inquiry, technological problem solving). Encourage students to recognize how the models for inquiry, problem solving and decision making:
  - parallel each other in the structure they provide for thinking
  - differ from each other in terms of their context for solving problems.

The following chart provides a comparison of scientific, technological and societal processes occurring in the real world.

	SCIENCE	TECHNOLOGY	SOCIETY/DECISION MAKING
TYPE OF ACTIVITY:	Theoretical	Practical	Practical
PROBLEMS ARISE FROM:	Curiosity about events and phenomena in the natural world	Wants/needs of individuals and society to accomplish specific tasks	Consideration of a broad range of interests in terms of the "common good"
RELATED QUESTIONS:	• Why does ...? • How do we know that...?	• What can we do to ...? • Will it work?	• What alternatives and consequences are there? • What should we do?
STRATEGY:	Scientific Inquiry	Technological Problem Solving	Deliberation/Consensus Building
OUTCOMES/ SOLUTIONS:	Knowledge about natural phenomena	Products and processes designed to achieve intended purposes	A defensible decision in the particular circumstances
EXAMPLES:	Why does milk sour? (Bacteria grows in milk. This bacterial growth causes illness and also causes milk to sour.)	What can we do to keep milk from souring and causing illness? (The process of pasteurization makes milk safe to drink and produces milk that tastes good.)	Should we require standards for the processing and handling of milk? (All commercial milk supplies must be pasteurized. The containers must be dated.)

SUGGESTIONS FOR USING THE DECISION-MAKING MODEL

Themes developed in this manual provide opportunities for students to develop and use decision-making skills within meaningful contexts. Students should recognize that the thought processes and skills used in making decisions are "lifetime tools", and when chosen according to purpose and need, are useful in many real life situations.

The following guidelines may be useful in helping students understand and use the decision-making model:

- Share the decision-making model with all students. The model provides structure to the overall process, as well as specific strategies/skills that might be used at each stage of the process. Familiarly with the model will increase the students' repertoire of strategies that can be utilized in resolving issues.

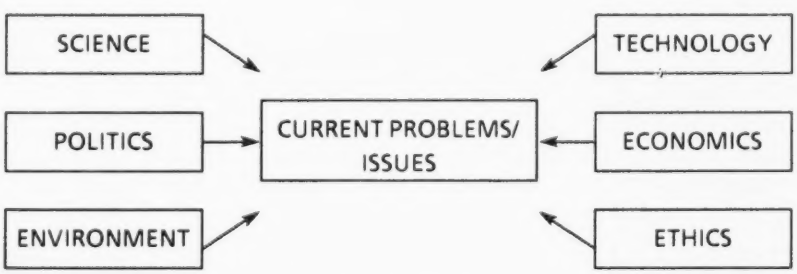
- Encourage students to be flexible in their approach to decision making. While useful in the structure it provides, the model should not be interpreted as consisting of fixed stages and strategies. Its use will depend upon individual issues and individual students.

- Make students aware of the thinking skills and thought processes that are useful in analyzing issues. Ask questions that encourage students to discover their own answers and model (talk through) complete thought processes that are used in resolving issues and making decisions.

- Select issues that are relevant in the local community and that relate to the student's personal experience. Gather data related to relevant issues through a variety of methods:
  - direct observation
  - reading/viewing
  - interview/discussion/debate.

  Ensure that students consider current perspectives on the issues they investigate by using the local media (e.g., newspaper, periodicals, television, radio).

- Encourage students to examine the advantages and disadvantages associated with the issues they investigate, and to avoid taking simple "for" and "against" positions. Students should recognize that there are often several ways of resolving complex issues. The following model may help to show the complexity of issues and offers a useful framework for their examination from different perspectives.



- Structure discussion and debate using the guidelines provided in Communication Skills, "Strategies for Discussing and Debating". Debating is a good technique to use in encouraging students to think carefully through complex issues. Deal appropriately with students who may dominate conversation, and encourage others who are hesitant about expressing their ideas to become involved. Ensure that discussion does not become a clash of personalities.

- modelling (talking through) the processes and skills that are appropriate to analyzing a particular issue
- discussing the processes and skills that the student is presently in the habit of using (i.e., raising the level of metacognitive awareness)
- encouraging students to develop additional strategies that will structure and support the thought process.

The model for decision-making should be explicitly presented to students as an overall process and used as a teaching and learning model when analyzing societal issues. The chart that follows suggests student activities that may be appropriate at each stage of decision making represented in the model.

UNDERSTANDING THE PROBLEM	• identifying issues • identifying/interpreting relationships • asking questions • identifying different perspectives or points of view (e.g., economic, political, ethical, scientific, technological)
DEVELOPING AND CARRYING OUT A PLAN	• researching issues – identifying alternatives – examining different perspectives on each alternative – gathering information about alternative technological products/ processes related to an issue – identifying/applying appropriate scientific knowledge. • reflecting and deciding – considering the consequences/implications of the alternatives – evaluating technological products/processes from different perspectives – evaluating the defensibility of an action – consensus building • taking action
REVIEWING AND APPLYING RESULTS	• evaluating the immediate effects of actions taken • evaluating the long-term consequences of actions taken • modifying actions to reduce or eliminate other problems • justifying/defending actions taken • evaluating the decision-making process

As relevant societal issues involving science and technology are investigated, encourage students to focus attention on:

- the probable long- and short-term consequences of particular technologies and/or actions
- strategies for assessing particular technologies and/or actions in terms of their advantages and disadvantages
- an awareness of various perspectives/possible solutions to complex issues.

Sample activities that encourage students to examine societal issues and use skills appropriate to the decision-making process are provided in:

- Resource 8: How Should We Access a Technological Process or Device?
- Resource 9: How Do We Make Decisions About Technology?

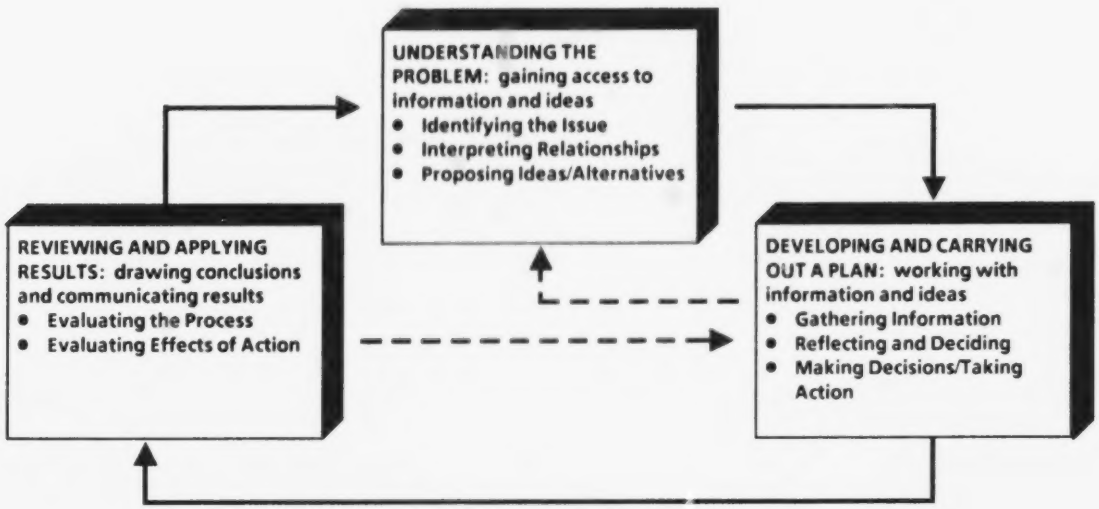
A MODEL FOR DECISION MAKING

Although science and technology give us tremendous ability, individuals and society must assume the responsibility of using this ability wisely. Some developments in science and technology, if inappropriately used, may force us to pay a price in terms of their effect on society and the environment. For example:

- the world's natural resources are being rapidly depleted
- our water and air are no longer pure and clean
- thousands of plant and animal species are threatened with extinction.

This does not imply that we should try to halt scientific and technological advancements. Rather, it draws attention to the importance of the decision-making process and the role of choice in resolving related problems in society. Issues influenced by science and technology need to be examined within the context of choosing the most appropriate actions for existing circumstances. Resolving these issues involves considering alternative proposals for action and evaluating their consequences. Scientific and technological knowledge can help inform deliberation about these proposals.

The science program should provide opportunities for students to examine relevant societal issues that involve science and technology, and to develop a process for resolving these issue and making responsible decisions The decision-making model that follows suggests an overall process for resolving issues. It provides a starting point and some ways of organizing thought and action.


UNDERSTANDING THE PROBLEM: gaining access to information and ideas
• Identifying the Issue
• Interpreting Relationships
• Proposing Ideas/Alternatives
DEVELOPING AND CARRYING OUT A PLAN: working with information and ideas
• Gathering Information
• Reflecting and Deciding
• Making Decisions/Taking Action
REVIEWING AND APPLYING RESULTS: drawing conclusions and communicating results
• Evaluating the Process
• Evaluating Effects of Action

Specific actions identified at each stage of the decision-making process represent possible strategies that might be used in deliberating and making a decision to act in a certain way. Students may not always use each stage of the process, and will select only those actions that are appropriate to purpose and ability. Students should, however, recognize decision making as a series of interrelated actions that lead to a defensible outcome.

By bringing thought processes to the metacognitive level (i.e., helping students to become aware of the thinking skills and thought processes that they and others use), students will be better able consciously to select and use those strategies and skills that are appropriate to the situations they encounter. Research strongly supports the teaching practice of:

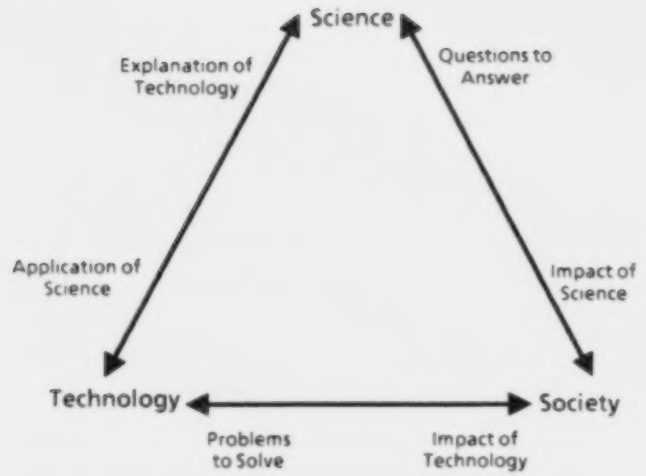
- the use of a technological process or device may depend upon the attitudes of individuals or society toward it.
  e.g., – food products such as the "chicken hot dog"
  – the recumbent bicycle
  – front-wheel drive automobiles.
- society often influences science and technology through the public funds it provides to support research and development in certain areas.
  e.g., – space exploration
  – medical research
  – energy research.

Learning activities should focus attention on how society influences science and technology at appropriate points throughout each theme. As particular technologies are studied, ask questions that will cause students to consider:

- individual/societal needs that led to their development
- attitudes that may have influenced their acceptance and use
- how public funds may have supported their development.

Sample activities that illustrate how society influences scientific research and technological development are provided in:

- Resource 6: Will No-Till Planting Be Accepted As a Farming Practice?
- Resource 7: Why Are Some Inventions Not Accepted by Society?



Students are asked to identify situations in which changes in either science, technology or society have affected the other two areas in Resource 3: How Do Science, Technology and Society Affect Each Other?

- Investigate the effects of technology on employment and career opportunities within each theme of the science program. Ask students to identify employment and career opportunities that:
  - have been created by technological change in the past ten years
  - have been modified by technological change in the past ten years
  - have become obsolete due to technological change in the past ten years.

  The activities provided in Resource 4: How Have Jobs and Careers Changed in the Last Thirty Years? and Resource 5: Where Are the Jobs and Careers? will encourage students to investigate changes in business, industry and employment that have been brought about by science and technology.

RECOGNIZING HOW SOCIETY INFLUENCES SCIENCE AND TECHNOLOGY

Science and technology do not act independently of society. Although the achievements of science and technology exert considerable influence on society, so does society either support or limit the progress of science and technology. Societal needs and concerns often initiate or direct technological problem solving and scientific inquiry. As societal values and attitudes change, so may motivation and support for research and development in particular areas change.

Learning activities should provide opportunities for students to recognize that:

- a technological process or device is usually developed in response to the needs of an individual or society.
  e.g., – vaccines against diseases
  – fast food restaurants
  – a special box to carry a frog to school

INTERACTIONS AMONG SCIENCE, TECHNOLOGY AND SOCIETY

RECOGNIZING HOW SCIENCE AND TECHNOLOGY INFLUENCE SOCIETY

We live in a rapidly changing society that is highly dependent upon science and technology. In fact, our world changes so rapidly that we sometimes fail to recognize that much of what we now take for granted existed only in the imaginations of people a few years ago. Advances in science and technology will make much of today's science fiction become reality within our lifetime. Furthermore, the changes that we experience and have become accustomed to are occurring at an increasing rate. It is predicted that these changes will continue and accelerate as we enter the twenty-first century.

CLARIFICATION/EXAMPLE

Developments in Science and Technology That Influence Society

- New biomedical advances make it possible to replace defective hearts, kidneys and other organs.
- The first flight lasted only a few seconds. Now, a little more than half a century later, space vehicles travel thousands of miles an hour to explore distant planets.
- Nuclear technology, of interest a few years ago because of its destructive potential, could soon provide use of almost limitless supplies of energy for peacetime needs.
- Computer technology has made it possible to solve, in seconds, problems that only a decade ago required many human lifetimes.
- Science and technology may, in the future, make it possible for us to control weather and other natural phenomena to varying degrees.

Instructional activities should provide opportunities for students to recognize the impact of science and technology on the nature of their lifestyle, their employment and career opportunities, as well as the quality of their environment. The activities that follow suggest ways of demonstrating how scientific and technological issues studied within various themes of the science program influence individuals and society.

- Ask students to identify situations in which a particular technology has:
  - improved their lifestyle
  - had a negative effect on their quality of life.

  Structure discussion and guide students through the processes of analysis and critical thought by using a "PMI" or a "CAF" (see Communication Skills, "Using Critical Thinking Skills").

  Activities provided in Resource 1: What Were the "Good Old Days" Really Like? and Resource 2: How Have Our Choices in Leisure Activities Changed? suggest strategies that may be useful in examining the positive and negative effects of science and technology on society.

- Identify a familiar development in the area of science, technology or society. Ask students to predict possible effects of this development on the other two areas.

  Students should recognize that science, technology and society are each part of an interdependent system, and that science and technology have a major role in society.

THE ROLE OF SCIENCE AND TECHNOLOGY IN SOCIETY

Science and technology influence many issues that we deal with individually and as members of society. Societal needs and concerns often influence technological problem solving and scientific inquiry. The science program must develop an understanding of the interactions among science, technology and society, and encourage students to appreciate the contributions and limitations of scientific and technological knowledge in resolving societal issues. Students should become familiar with the decision-making process, and gain experience in its use by examining relevant issues in the local community that are related to science and technology.

Learning activities used throughout the science program should enable students to recognize:

- the impact of science and technology on lifestyle, occupational choice, environment and welfare
- that personal and societal needs/attitudes influence science and technology
- that science and technology help inform the societal decision-making process
- that societal decision making aims at choosing actions most appropriate for existing circumstances by comparing and evaluating the consequences of alternative proposals
- that the societal decision-making process works toward building a consensus. Significant aspects of social decision making include:
  - recognizing the advantages and limitations of scientific and technological knowledge in informing the process
  - considering other perspectives (e.g., economic, ethical, political) in informing decision making about science-related issues
  - deliberating in order to clarify, support, modify or reject alternative proposals for action
  - recognizing the need for trade-offs in order to achieve workable solutions in science/technology/society problems
- that often the products of science and technology are accepted and used by society before the full extent of benefits/problems resulting from their use can be fully known.

Local issues should be selected for investigation on the basis of the opportunities they provide for students to:

- appreciate the beauty and complexity of living things
- recognize the interdependence of life forms
- recognize the need for resource conservation
- appreciate the need for informed decision making at both personal and societal levels
- develop confidence in using scientific and technological knowledge to inform personal decision making
- appreciate different perspectives that bear upon the societal decision-making process
- respect the perspectives and viewpoints of others
- realize that the solution to one problem may result in the creation of another problem.

A variety of teaching and learning strategies that may be used to illustrate how science and technology influence and are influenced by societal issues have been included in this section of the manual. Content supports active involvement in the decision-making process, and includes:

- Interactions Among Science, Technology and Society
  - Recognizing How Science and Technology Influence Society
  - Recognizing How Society Influences Science and Technology
- A Model for Decision Making
- Suggestions for Using the Decision-Making Model.

RESOURCE 9: HOW DO WE MAKE DECISIONS ABOUT TECHNOLOGY?

PURPOSE

To show that a complex technological issue has several possible solutions and that trade-offs are often made among these solutions.

MATERIALS

Reference books and magazine, recent newspaper articles about technological issues.

PROCEDURES

1. Read several magazine and newspaper articles about one of the following technological issues:

   - the need for additional amounts of energy
   - disposal of toxic wastes
   - disposal of radioactive wastes
   - contamination of ground water supplies
   - artificial organs.

2. As a class, discuss and describe alternative courses of action for the technological issue.

3. As a class, decide which alternative courses of action should be followed. You may have to come up with a compromising course of action.

4. Answer the following questions:

   a. How difficult was it to make a group decision about the proper course of action?
   b. To what degree did individuals have to make compromises?
   c. If experts were to become involved in making decisions about this issue, from what disciplines might they come? To what extent do you think these experts would agree on the solution?

5. Invite a person who is involved with policy making to speak to the class about how individuals and government make decisions and set policy.

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COMMUNICATION SKILLS

The strands of language (i.e., listening, speaking, reading, writing, viewing and metacommunication) play an important part in the teaching and learning of science. Not only is language a means of communication, but it is also part of the thinking process used to combine ideas, find relationships, ask questions and solve problems. Language development in Science 8 and 9 must parallel its development in Language Arts 8 and 9, through use of strategies that are often similar to those used in the language arts class.

A variety of teaching and learning strategies useful in gathering, interpreting, recording, evaluating and communicating ideas in science are provided in this section of the manual. Teachers are encouraged to familiarize themselves with these strategies. By modelling and teaching appropriate "learning to learn" strategies at strategic points within each theme of the science program, teachers can support students in their use of language and thinking skills.

CLARIFICATION/EXAMPLE

An Approach to Teaching a Learning Strategy (Deshler, 1979)[1]

1. Test students on a task that requires the use of the strategy to be taught. Discuss the results with students, and point out strategy deficiencies.
2. Describe the steps involved in the target strategy. Details should include appropriate behaviours, their sequence, and ways in which the strategy will help the student.
3. Model the strategy for students. Teachers should "think aloud" so that students can become aware of all processes involved in the strategy.
4. Ask students to "verbally rehearse" the strategy.
5. Provide opportunities for students to practise using the strategy through controlled activities. Use instructional materials that match the students' reading level.
6. Provide positive and corrective feedback to students as they apply the strategy.
7. Provide opportunities for students to apply the strategy using more difficult materials that are grade-appropriate.
8. Provide positive and corrective feedback to students as they practise applying the strategy to grade-appropriate material.
9. Re-test students on their use of the strategy. Use the test given in Step 1 with different instructional materials.

The teaching and learning strategies that follow are similar to those used in developing communication skills in other subject areas, and include:

- Reading and Viewing Science Materials
  - A Study Guide for Reading in Content Areas
  - Assessing Readability
  - Comprehension Strategies
  - Developing Technical Vocabulary
  - Using Advance Organizers/Conceptual Overviews
- Summarizing, Evaluating and Communicating Ideas in Science
  - Making Summaries
  - Using Critical Thinking Skills
  - Giving and Following Directions
  - Strategies for Discussing and Debating
  - Informal Essay Writing.

1. Alley, Gordon and Deshler, Donald, *Teaching the Learning Disabled Adolescent: Strategies and Methods*, Love Publishing Co., 1979.

READING AND VIEWING SCIENCE MATERIALS

The precision of vocabulary and symbols used in science is often a source of difficulty. The everyday meanings associated with words often interfere with an understanding of special meanings a word may have in science. Each theme of the science program should be analyzed in order to identify demands relative to vocabulary and symbolic content. Discussion of common base words, prefixes and suffixes may assist students to identify/recall the meanings of technical words used within the theme. The following questions will be useful in planning activities that provide for an understanding of technical vocabulary being used.

- How does this vocabulary relate to everyday usage?
- How does it conflict with everyday usage?
- How does it relate to previously studied science terms?

The role of experience in developing concepts must be recognized in vocabulary development activities. Definitions may be developed as summarizing statements of ideas that have been understood, but should not be used as introductions to new vocabulary or symbols. Students should be encouraged to explain the meanings of new words through their own language, and to draw upon personal experience in giving examples of how the word is correctly used. The following instructional sequence might be used to foster meaningful vocabulary development, and to ensure that each word or symbol introduced becomes part of the student's active or "working" vocabulary.

- Discuss real life examples from the student's environment where the word/symbol might be used.
- Simulate concrete and transitional models where the word/symbol might be appropriately used.
- Discuss and list distinguishing characteristics of the word/symbol.
- Record the word/symbol and its distinguishing characteristics (meaning) in a personal science "glossary".

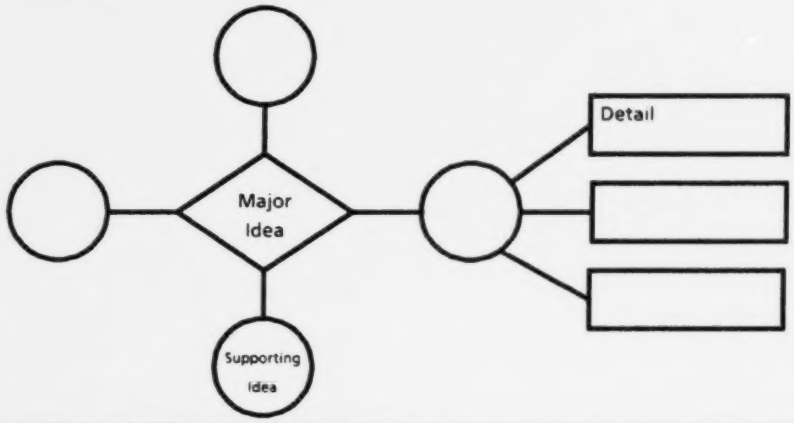
When reading and viewing science material for content, new material must be assimilated into the student's existing knowledge. Introductory questions and activities that focus attention on "what I already know" can prepare the student for reading material that provides answers to "what I need to know". Students might be guided in their reading/viewing for content and information through activities that include the following steps:

- decide on a purpose for reading/viewing. State the purpose as a question
- skim the whole section to get an idea of how it is organized
- notice various "aids to reading/viewing" that have been used in the material (e.g., headings, colour, bold print, diagrams, charts, coloured pages)
- after reflecting on purpose, decide which sections need intensive study and which may be delayed or skipped
- engage in "active" reading/viewing of the material (e.g., ask questions, think of examples, rephrase in everyday language).

Inquiry and problem solving often necessitate that relationships and patterns be identified through reading and viewing. Such processes place cognitive demands upon the student that can often be a source of frustration. Instruction must provide strategies that will assist students in identifying major and supporting ideas, their relationships, and in making inferences and predictions on the basis of information obtained through reading and viewing. "Semantic webs" and "concept circles" are useful in structuring comprehension activities, and can be used to help students organize, interpret and integrate information gathered.

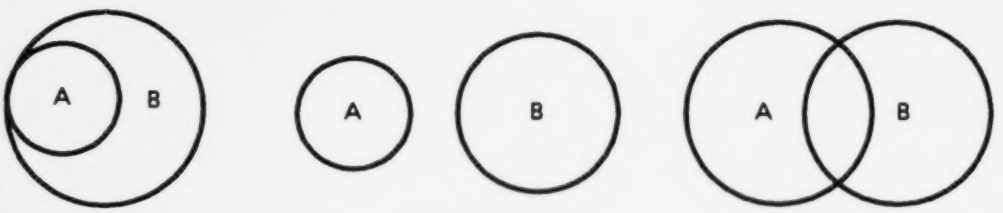
CLARIFICATION/EXAMPLE

A Simple Web Configuration



CLARIFICATION/EXAMPLE

Illustrating Relationships With Concept Circles



all A is B
(some B is not A)

no A is B
(no B is A)

some A is not B
(some B is not A)

Additional strategies that will assist in the development of reading and viewing skills used in science are provided in:

- Resource 1: A Study Guide for Reading in the Content Areas
- Resource 2: Assessing the Readability of Science Materials
- Resource 3: Comprehension Strategies
- Resource 4: Developing Technical Vocabulary
- Resource 5: Using Advance Organizers/Conceptual Overviews.

SUMMARIZING, EVALUATING AND COMMUNICATING IDEAS IN SCIENCE

The communication skills used in summarizing, evaluating and communicating ideas in science are similar to the skills required of most students in other subject areas. Students should be given opportunities to describe relationships, patterns and the results of inquiry, problem solving and decision making through a variety of writing activities. The use of language can be strengthened through questions that probe for explanations rather than stimulate recall of information. Students should frequently be asked "why?", and be encouraged to use writing skills in expressing their ideas and interpretations.

CLARIFICATION/EXAMPLE

Questions That Involve Students in Investigation

- What are we looking for?
- What do we want to explain/investigate?
- What do you notice about this ...?
- What do you think might happen if ...?
- Why did ...?
- What should we do first?
- What is stopping us?
- If this is so, then ...?

Questions That Stimulate Creative Response

- What is my next step?
- How will I do that?
- How can I design a better ...?
- What is the relationship between ... and ...?
- Why did ... happen after ...?
- How would you design an experiment to ...?
- What might happen if you use ... instead of ...?
- What is the likelihood that ...?

Questions That Stimulate Analysis and Evaluation

- How did you know that ...?
- What does the data indicate?
- What caused ... to happen?
- How does ... apply to ...?
- How could you explain ... in another way?
- How might you use these results?
- How could we make our work easier another time?
- How could we improve it or make it better?
- What should we tell others?

A variety of writing activities are suggested within each theme of the science program. These activities provide for experience in:

- summarizing (e.g., note-taking)
- describing (e.g., recording observations)
- giving and following directions (e.g., logical sequencing)
- writing a laboratory report (e.g., writing directions/descriptions)
- informal essay writing (e.g., expressing an opinion, supporting a point of view).

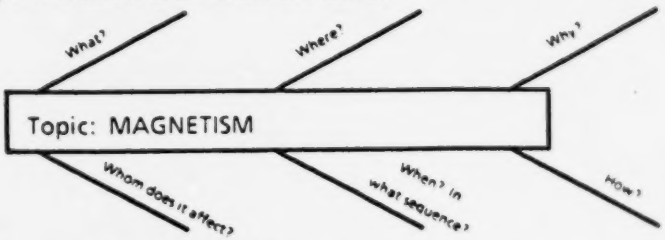
Of particular importance are skills in summarizing or note-taking, for the way students record information in class can have a major effect on how well they process and remember it. Note-taking from books, lectures, visual presentations and laboratory experiments reorganizes knowledge, enhances memory and maintains attention during instruction. Although note-taking styles may vary according to purpose and ability, provide opportunities for students to develop and extend their note-taking skills by:

- modelling the use of appropriate note-taking styles. Show students how you would take notes.
- taking notes together with the class. Illustrate a note-taking process using a text reading, a filmstrip, or even an experiment. Compare and contrast your notes with those of the students.
- asking students to take their own notes while you closely monitor their work. Correct their mistakes when necessary.
- requiring students independently to take notes during class. Give assignments that require note-taking. Include a note-taking passage on each exam.

CLARIFICATION/EXAMPLE

A Note-Taking Style

In the "herring bone" style, a fish spine becomes a visual analogy to describe a specific scientific topic. Each bone holds a word that requires an explanation. Students may record very little information on one bone, and a lot of information on another bone. They may write above and below the bones.



- What? – What is magnetism?
- Where? – Where does it occur?
- Why? – Why does it work the way it does?
- Who? – Who is affected?
- When? – When does it work? In what sequence?
- How? – How does it work?

Additional strategies that will assist students to develop skills used in summarizing, evaluating and communicating ideas in science are provided in:

- Resource 6: Making Summaries
- Resource 7: Using Critical Thinking Skills
- Resource 8: Giving and Following Directions
- Resource 9: Strategies for Discussing and Debating
- Resource 10: Informal Essay Writing.

RESOURCE 1: A STUDY GUIDE FOR READING IN THE CONTENT AREAS

STUDY GUIDE

1. Suggest a different title for the article you have just read. Try to capture the essence of the article in your title, but keep it short.

2. Two key ideas or concepts discussed in this article are:
   - _____
   - _____

3. Three details or facts you would like to remember from this article are:
   - _____
   - _____
   - _____

4. What did you find especially interesting or surprising in the article?

5. What word or words from this article do you think the author chose rather carefully?

6. Indicate any words, sentences, or paragraphs in the article you would like to discuss in class or have explained:

   Page: _____ Line: _____

7. If you could talk to the author of this article, what questions would you ask or what comments would you make to him or her?

8. What mental images did you form while you were reading this article?

9. Rate this article by marking an X on the line at the point that indicates your evaluation.

   Very ◄——————————————► Not very

Interesting: _____

Informative: _____

Easy to Read: _____

This study guide by Smith[1] can be modified to suit the needs and abilities of students, the characteristics of the reading assignment, and the instructional objectives. Note that the type of questions asked of students does not permit simply scanning the selection to find answers. Students enjoy sharing their responses in small groups or through class discussion

1. Smith, Richard J., *A Study Guide for Extending Students' Reading of Social Studies Material*, The Social Studies Vol. 78, No. 2, p. 85-87.

RESOURCE 2: ASSESSING THE READABILITY OF SCIENCE MATERIALS

Teachers may find it necessary to supplement textbook activities with appropriate articles and materials from other sources. In assessing the overall readability of these materials, it is important to recognize factors that may contribute to the ease or difficulty with which students can read and comprehend the material. Reading involves complex interactions between student and text.

Student-related considerations include:

- background knowledge/preparedness for the reading task
- motivation
- interest.

Text-related considerations include:

- vocabulary (e.g., level of difficulty, word length, jargon, technical language)
- conceptual depth
- syntax (e.g,. sentence structure)
- format (e.g., margins, bold type, italics, headings, underlinings)
- organization (e.g., chapter summaries, pre- and post-questions, word lists, glossaries)
- key visuals (e.g., pictures, charts, graphs, tables).

Acknowledging and making necessary adjustments to the student- and text-related considerations listed above will result in a supportive, appropriately challenging reading environment in science. Readability data should be used to alert teachers to areas of possible difficulty, and the need to provide reading comprehension aids.

READABILITY FORMULAS: SMOG AND FRY

Readability formulas generally reflect text difficulty in terms of the length of sentences and words. Two formulas are provided for teacher use:

- the SMOG Formula
- the Fry Readability Graph.

These formulas might be used in conjunction with other methods of assessing the appropriateness of reading materials in science.

THE SMOG FORMULA

This formula, described by McLaughlin (1969) as a "simple measure of gobbledegook", is a simple technique:

1. Near the beginning of the text, count 100 consecutive words; then count 100 consecutive words in the middle and 100 near the end of the text (approximately five sentences in each section).

2. Tabulate the number of words consisting of three or more syllables. If a word is repeated it should be included in the count.

3. Determine the square root of the number of the polysyllabic words that have been counted. McLaughlin suggests that this be done by taking the square root of the nearest perfect square. If the count lies roughly between two perfect squares, choose the lower number.

4. Finally, add 3 to the estimated square root. The resulting number will give an estimate of the reading level a student should have attained (independent level) in order to fully comprehend the material fully.

THE FRY READABILITY GRAPH

1. Randomly select three sample passages and count out exactly 100 words in each, starting with the beginning of a sentence. Include proper nouns, initializations and numerals.

2. Count the number of sentences in each passage of one hundred words, estimating length of the last sentence as a fraction to the nearest tenth.

3. Count the total number of syllables in each 100-word passage. If you don't have a hand counter available, simply put a mark above every syllable over one in each word. Then count the number of marks and add 100. A calculator can also be used as a counter by pushing the number "1" and the " + " sign for each word or syllable when counting.

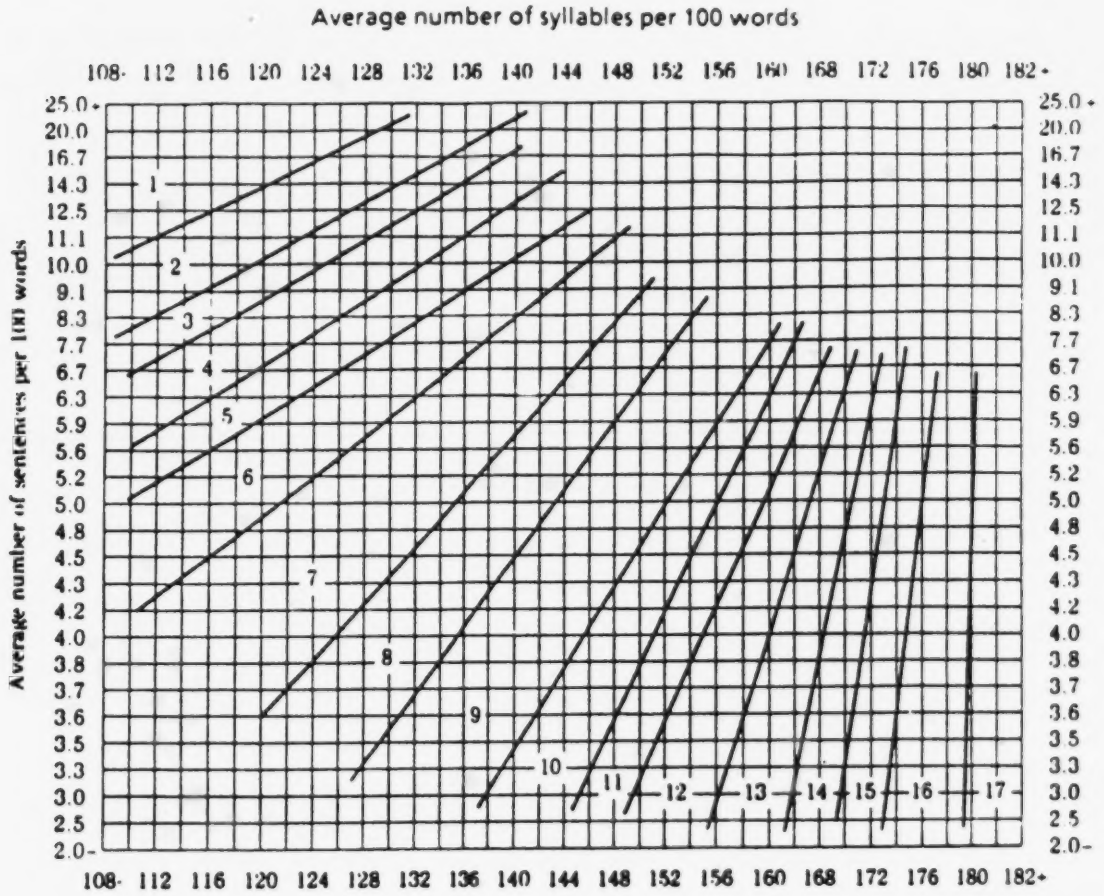
4. Determine the average number of sentences and average number of syllables per 100 words. Plot a point where the two lines intersect on the readability graph provided on the next page. The area where the dot is plotted represents the approximate grade level.

5. If a great deal of variability is found in the syllable count or the sentence count, it may be desirable to put more samples into the average.

6. A word is defined as a group of symbols with a space on either side; thus, Joe, IRA, 1945, and & are each one word.

7. A syllable is defined as a phonetic syllable. Generally, there are as many syllables as vowel sounds. For example, stopped is one syllable and wanted is two syllables. When counting syllables for numerals and initializations, count one syllable for each symbol. For example, 1945 is four syllables, IRA is three syllables, and & is one syllable.

THE FRY READABILITY GRAPH



USING A CLOZE PROCEDURE

The **cloze procedure** was developed by Wilson Taylor (1963)[1] as a tool for testing reading comprehension. In a modified form, the procedure may be suitably used in science to:

- measure readability
- test for comprehension
- diagnose individual reader's abilities or deficiencies.

PROCEDURE FOR DEVELOPING AND ADMINISTERING A MODIFIED CLOZE

1. Choose a reading passage of approximately 350 words. The passage should be one that students have **not** previously read.

2. Leave the first two sentences intact and delete every **seventh** word thereafter (**A, an** and **the** are not to be deleted. Instead delete the next word.) Leave the last sentence intact.

3. Retype the selection replacing the deleted word with a blank of standard length (12 letter spaces).

4. Have the students read the passage and fill in the blanks. This activity should not be timed.

5. Count the number of correct responses. The wording must match the original **exactly**. Spelling, however, does not count.

6. Calculate the percentage of correct responses.

7. Use the following **guidelines** to estimate students' ability to read **narrative-style** material effectively. (These scores are not to be treated as rigid cutoff points).

60-100 percent:	independent level – the student can read without help
45-60 percent:	instructional level – the student can read with help
0-45 percent:	frustration level – unsuitable for reading

8. Use these **guidelines** to estimate students' ability to read **expository**-style material (e.g., material containing explanations of concepts).

55-100 percent:	independent level
40-55 percent:	instructional level
0-40 percent:	frustration level

1. Taylor, W.L. "Cloze Procedure: A New Test for Measuring Readability". Journalism Quarterly, 30, Fall, 1963, pp. 415-433.

ALTERNATIVE TECHNIQUES FOR USING THE CLOZE PROCEDURE

1. The Maze Technique (Feely, 1975)[2]

   Offer a multiple choice format for each blank. Three alternatives are provided for each blank in random order: 1) the correct word; 2) an incorrect word of the same grammatical class (e.g., verb, noun, preposition); and 3) an incorrect word of a different grammatical class. The maze is more difficult to prepare, but it is less threatening, and easier for students to complete than the cloze procedure previously described.

   e.g., Many _____ (numbers, varieties, sleek) of wildcats are found on the continents of Africa and Asia including lions, tigers and leopards.
   (answer – varieties)

   Suggested maze readability cutoff points are:

92-100 percent:	independent level
80-91 percent:	instructional level
75 percent or less	frustration level

2. The Cloze Procedure with a Word List

   Prepare a reading passage following the steps previously outlined. Provide a list of the deleted words, in random order, from which students can select the appropriate word for each blank. This alternative may also prove less threatening to students. A sample cloze procedure with a word list follows.

   Note: With all techniques, the key to using the cloze as a tool for developing reading skill is discussion after completion of the exercise. Students should be encouraged to verbalize reasons for selecting a particular word. Immediate reinforcement and feedback regarding the correctness of the students' guesses and the strategies the students used to arrive at their answers will make the cloze an excellent teaching technique in science.

2. Feely, T.M. "How to Match Reading Material to Student Reading Levels: The Cloze and the Maze", Social Studies, 66, 6, November/December, 1975, pp. 249-252.

A SAMPLE CLOZE PROCEDURE

CAREERS[3]

The transportation technology industry offers a variety of occupational opportunities. Jobs in this field include service station attendants, technical assistants, skilled and semiskilled workers, service and repair personnel, scientists, inventors, and engineers.

The amount and type of training _____ with each job. So does the _____ you can expect to earn.

Professional

_____, researchers, engineers, teachers, and high-level _____ are examples of professional positions. College _____ is required for these careers.

Mechanics

Mechanics _____ small engines that are used to _____ lawn mowers, garden machines, and _____ small machines.

A mechanic must know _____ to use hand tools and measuring _____. A mechanic must be able to _____, to disassemble engines, to examine parts _____ defects, and to repair or replace _____ parts.

Skilled Workers

Skilled workers include diesel, _____, and aircraft mechanics. Lengthy on-the-job _____ and/or apprenticeship programs are required.

_____ machine operators are classified as **semiskilled** _____. A machine operator requires considerable on-the-job _____.

Little or no training is required _____ **unskilled** workers. Labourers, labour helpers, and _____ station attendants fall into this group.

Self-Employment

_____ small engine technicians are self-employed. _____ often begin on a part-time _____. They learn about small engines by _____ their own engines and those of _____ friends and neighbors. Then they expand their _____ to other customers.

Operating your own business _____ many advantages. You do not have _____ report to anyone else. You _____ set your own hours. You keep _____ the profits. However, owning your own _____ is very hard work. It requires business skills as well as mechanical skills.

WORD LIST

varies	how	workers	their
salary	tools	training	business
scientists	troubleshoot	for	offers
managers	for	gas	to
education	defective	many	can
repair	automotive	they	all
power	training	basis	business
other	basic	servicing	

A total of 31 words were omitted from the foregoing selection, Using the guidelines for **expository** style material:

- a score of 18 or better indicates the student is reading at the **independent** level
- a score of 10 to 17 indicates the student is reading at the **instructional** level
- a score of 0-9 indicates the student is reading at the **frustration** level.

3. For permission to adapt copyrighted material, grateful acknowledgement is made to Glencoe Publishing Company, Los Angeles, U.S. for the excerpts from *General Industrial Education*, by Los Angeles Unified School District, 1988, p. 54.

RESOURCE 3: COMPREHENSION STRATEGIES

QUESTION-ANSWER-RELATIONSHIP (QAR) STRATEGY

Students may have difficulty comprehending text if they lack strategies for answering questions related to the print material. The **Question-Answer-Relationship Strategy** (Raphael, 1982)[1] assists students to connect the questions to the text or to present knowledge they possess. In addition, QAR is a strategy students may use to locate the information needed to answer questions.

Throughout all three QAR question types, students must first determine the location of the answer. The answers to Type 1 questions are explicit in the passage and may be found by scanning the text. Students must integrate known information with the text to answer Type 2 questions. Type 3 questions provide opportunities for students to make inferences. Practice in using the following three QARs have been shown to significantly improve students' ability to process print information.

WHERE IS THE ANSWER FOUND?

Type 1

Right There

The answer is explicit in the story and therefore easy to find. The words used to make the question, and the words that form the answer are "Right There" in the same sentence.

Type 2

Think and Search

The answer is in the story, but is a little more difficult to find. The words in the question and the words in the answer are never in the same sentence. Students would have to "Think and Search" for the answer.

Type 3

On My Own

The answer will not be told by words in the story. Rather, it must be found using background information and/or predictions. Students will think, "I have to answer this question 'On My Own'. The story will not be very helpful."

TEACHING SUGGESTIONS:

1. Introduce the QAR concept and terminology. Use the above figures to discuss the difference between text-based and knowledge-based responses. Stress the differences between the two text-based strategies.

1. Raphael, Taffy E. "Question-Answering Strategies for Children", The Reading Teacher, Nov. 1982, pp. 186-190.

2. Practise the strategies with reading materials, using a question from each QAR category. (The specific type of QAR should be identified for the students.) Discuss why the questions and answers represent their respective QARs.

3. Select and distribute reading materials in science with questions. Have students identify the QAR for each question. It is important for students to develop the ability to justify their responses on the basis of the text and individual background knowledge.

4. Continue to practise the strategies with longer selections of written material (600-800 words), from science.

PARAPHRASING (RAP) STRATEGY[2]

DESCRIPTION OF STRATEGY

R – The students **read** the paragraph silently to themselves.

A – After reading the paragraph, the students stop and **ask** themselves what they just read (e.g., Does it make sense? How does it relate to what I already know? How does it relate to what I have already read? What is the main idea the author is trying to get across?).

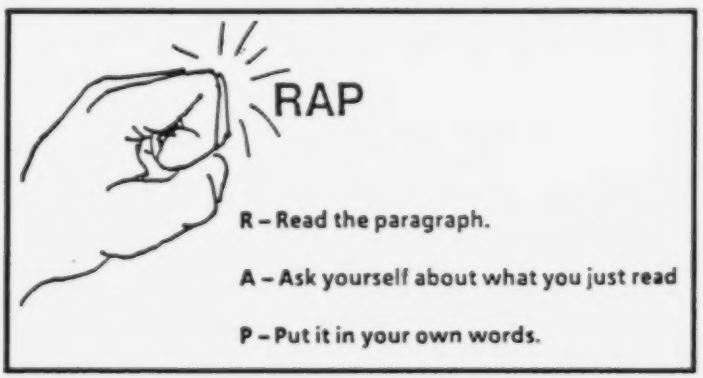
P – Notes are then written based on what has been read and asked, using the student's own words.

SUGGESTED APPLICATION

This strategy can be used to help students remember more of what they read. The strategy is particularly useful for material with much detail, material that is abstract, for note taking and for studying.

TEACHING SUGGESTIONS

Give students an article to read. Ask them to remember what they've read. The next day, give them comprehension questions based on the article. Record their scores. After RAP has been taught, give students an article and ask them to "RAP" it. The comprehension questions are given again the next day. A comparison of scores should illustrate the effectiveness of "RAP" for improving both comprehension and retention.



2. Adapted from *SPELT: A Strategies Programme for Effective Learning and Thinking Inservice Edition*, SPELT International Ltd., p. 145. Copyright 1987 by R. Mulcahy, K. Marfo, D. Peat, and J. Andrews. Reprinted by permission.

CHAPTER ATTACK (SQ3R) STRATEGY

SQ3R is a study method designed by Robinson (1946)[3], and represents "Survey, Question, Read, Recite, Review". The steps involved in the SQ3R approach are:

1. **Survey.** Notice chapter titles and main headings before you actually read the assignment. Then read introductory and summary paragraphs, and study graphs, charts, etc. This initial survey provides a framework for organizing facts.

2. **Question.** Formulate a list of questions to be answered when reading the passage.

3. **Read.** Read the passage to answer the questions.

4. **Recite.** Try to answer the questions without looking at the material you have read.

5. **Review.** Verify or correct your recited answers by rereading the passage and noting the main points and the relationships that exist among various points.

This method helps students remember content material. SQ3R works well with more competent readers.

SQ3R (Chapter Attack Strategy)

1. **Survey – quickly read;**
   a) **chapter introduction (BEGINNING)**
   b) **chapter summary (END)**
   c) **first sentence in each paragraph**
   d) **visual aids (pictures, graphs, diagrams)**
2. **Question – ask a question based on each sub-title**
3. **Read – read each section to find the answer to your question**
4. **Recite – write down the answer**
5. **Review – say or write a summary of what you've learned**

3. Robinson, F.P., *Effective Study*, Harper Brothers, New York, 1946.

STRATEGIES FOR USING CONTEXT CLUES

Extracting meaning from context clues involves understanding the redundancy features of language. Students must shift from seeing reading as a process of decoding print, to seeing reading as a process of extracting meaning.

Smith (1978)[4] states that redundancy has four components:

- the visual system – what the word looks like
- the semantic system – the meaning of the word
- the syntactic system – the use of grammar
- the orthographic system – the spelling of the word.

All readers need to make use of these four systems to ensure success at extracting meaning from context clues.

Model a strategy for using semantic clues by talking aloud to explain the thinking process. (Explicit teacher explanations are associated with higher awareness of lesson content and greater achievement.)

While instructing students to look for context clues, the teacher may say:

> T: ". . . look for clues in the context. Remember, the context refers to the words before the new word or the words after the new word. Sometimes they are words in a different sentence close to the new word."
>
> The teacher continues to verbalize personal thoughts while using the strategy and emphasizes that a mental process is to be used:
>
> T: ". . . put the clues together with what you already know about that word and decide on the meaning."
>
> Finally, the teacher should emphasize learning the skill and process so that it can be used to read outside of the class:
>
> T: "This is a skill you can use while reading material such as the newspaper, your science book, or a library book. Any time you find a word that is new to you, use this skill to determine its meaning."

Supervised practise with a modelled strategy is necessary to ensure its continued use and transferability.

4. Smith, Frank. *Understanding Reading*. Holt, Rinehart and Winston, N.Y., 1978.

RESOURCE 4: DEVELOPING TECHNICAL VOCABULARY

VOCABULARY SELF-COLLECTION STRATEGY

Junior high school appears to increase demands that are placed upon students to acquire an expanded and refined vocabulary. Developing technical language and gaining understanding of the specialized meanings of common words are examples of these demands.

To assist students in developing their vocabulary:

- instruction should be directed toward vocabulary students need to know - they can often identify these words themselves
- instruction should give students the skills necessary for continued and independent vocabulary growth.

The Vocabulary Self-Collection Strategy (Haggard, 1982)[1] satisfies both of these conditions. Follow these steps:

1. Have each student identify two words they believe the entire class should understand. The teacher will also bring two words. Students are encouraged to choose words they hear or see in their own environment (e.g. words heard on television, in conversation, in a textbook, in a magazine, or in the newspaper), thus placing an emphasis on words in context.

2. Ask students write their words on the chalkboard. Each student will identify their own words, where they were found, and why the class should understand these words.

3. Reduce the number of words on the chalkboard by eliminating duplications and words that are known by the majority of class members. Keep high frequency words or words judged to be highly important by the majority of the students.

4. Ask individual students to suggest meanings for the words remaining on the chalkboard.

5. Discuss the definitions with the class so as to clarify, refine or extend word meanings. During this process, students should record the words in a personal vocabulary journal, along with their meanings as discussed in class. (Individual students may choose to retain one or more words which were eliminated from the original list.)

6. Use the new words in a variety of ways to provide practice (e.g., make or solve crossword puzzles, write sentences and dialogues).

7. Test student retention of vocabulary at the end of the week. Repeat the cycle as necessary.

One value of this strategy is that it helps to identify words that really cause problems for students. Often, the words identified by students do not coincide with those a teacher or textbook author would isolate as being difficult.

1. Haggard, Martha. "The Vocabulary Self-Collection Strategy: An active approach to word learning", Journal of Reading, December 1982, pp. 203-207.

TEACHER INTERACTION TECHNIQUE

The teacher interaction technique (Eeds and Cockrum, 1985)[2] is designed to connect a new word to existing schema in each student's repertoire of vocabulary knowledge. This technique of word meaning instruction helps learners fit new words into an already existing conceptual framework through the following sequence of steps:

1. Prior to beginning a reading assignment, identify the difficult words in the reading selection and choose the words that may become internalized using this strategy (e.g., words lacking in contextual support from which students can determine meanings on their own).

2. Organize a situation where a conceptual network common to most students will be activated (e.g., a situation for the word "peculiar" may be presented as follows: "Have you ever had an experience that made you sit back and say that it was one of the strangest experiences you have ever had? Tell me about it". Listen to several examples of strange happenings and label them "peculiar").

3. Have students write about an event they have heard of or experienced which they personally found very peculiar.

4. Encourage students to write about something that is *not* peculiar (a non-example).

5. Ask students to define "peculiar" in their own words.

   These five steps -- identifying difficult words, activating common experiences, connecting the new word to individual experience, contrasting with a non-example, and translating the meaning into personal language, appear to positively influence the acquisition of new vocabulary.

The teacher interaction technique has been effectively used with students identified as "low ability". Research indicates that students using this strategy outperformed other students who were given the same vocabulary items to learn using the dictionary to gain meaning, or who were left to gain meaning incidentally by reading for context clues.

2. Eeds, Maryann, and Ward A. Cockrum. "Teaching Word Meanings by Expanding Schemata vs Dictionary Work vs Reading in Context", Journal of Reading, March, 1985, pp. 492-497.

VOCABULARY SORTING

The steps that follow suggest a strategy for developing an understanding of technical vocabulary through the use of "word sorting" activities:

- Give students a list of vocabulary items and ask them to categorize the words. Alternatively, ask students to generate their own list of technical or specialized vocabulary from a science topic studied.
- Give category headings, or ask students to decide on their own headings. Indicate to students that more than one classification scheme is possible, and that any tabulation scheme which they can justify is acceptable.
- Record any questions that arise during the categorization process.
- If vocabulary items are new to students (i.e., this would be a pre-reading activity), it is best to present the words in context. Students should scan the text, list the new words, and then use this as a basis for the vocabulary sorting exercise.

EXAMPLES OF VOCABULARY SORTING ACTIVITIES

The following vocabulary items are commonly used in the study of technologies related to the automobile.

1.	points	plugs	tune-up	condenser	motor
2.	cables	battery	terminals	acid	plates
3.	steering	ball joints	tie rod	front suspension	seals
4.	fender	trunk	hood	grill	body
5.	lubrication	grease	oil	filter	drain
6.	accessories	air conditioning	AM-FM	defogger	clock
7.	tire	hubcap	jack	flat	wrench
8.	gauges	odometer	alternator	temperature	fuel
9.	bench	bucket	seat	front	rear
10.	coolant	thermostat	drain	radiator	cooling system

1. Have students circle the **"Main Idea"** word in each of the ten groupings above.
2. Extract the **"Main Idea"** words from the groupings above and present them as category heading. Scramble the rest of the vocabulary items and have students sort them under the headings.
3. Scramble all of the vocabulary items, and have students attempt to identify both the **"Main Idea"** words (i.e., category headings) and the "sub-topic" words.

MAKING A CROSSWORD PUZZLE OR A WORD FIND

Step 1: Identify a given list of words or make a list of words that pertain to a particular topic.

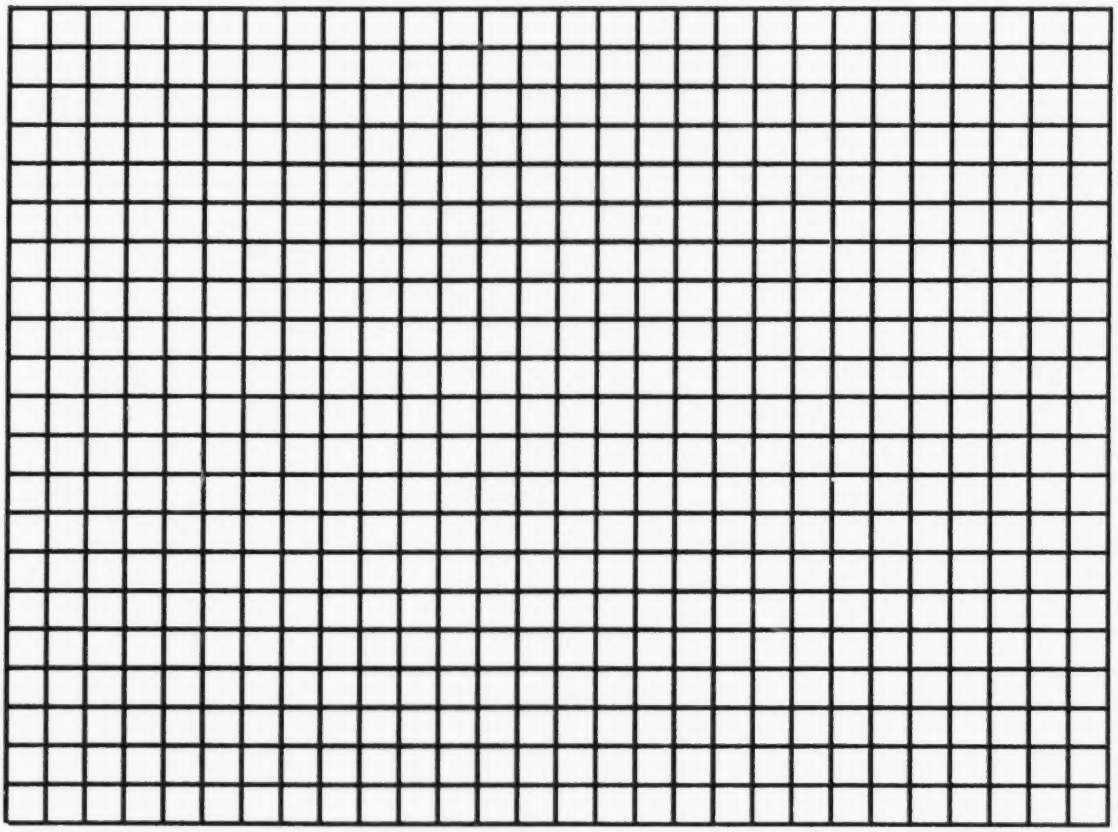
Step 2: Write the words on the grid, interlocking letters as often as possible, going across and down the page.

Step 3: Lay another sheet of paper over the grid and trace only those squares that contain letters. Or, with a felt tip marker, shade unused squares to form dark background.

Step 4: Number the first square of each word in the upper left corner.

Step 5: Number the "clues" or definitions in the same order as the words are numbered on the grid and place clues at the bottom or on a separate sheet of paper.

Crossword Puzzle Grid



Word Identification (WIS) Strategy[3]

Description of Strategy

To be used as a word attack strategy, when you don't know how to read a word.

Step 1 – Look at the word in the sentence. Can I guess at what it is by reading the words around it?

Step 2 – Look for a prefix. Look at the beginning of the word. Say it.

Step 3 – Look for a suffix. Look at the end of the word. Say it.

Step 4 – Locate the stem. Look at what's left after locating the prefix and the suffix.

Step 5 – Attack the stem. You do this by:

a) Using the rule of 2's and 3's. If the stem starts with a vowel, say it with 2 letters; if with a consonant, say it with 3 letters.

b) Two vowels together sound like one – try both sounds.

Step 6 – Look in a dictionary. Or

Step 7 – Ask someone.

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RESOURCE 5: USING ADVANCE ORGANIZERS/CONCEPTUAL OVERVIEWS

SEMANTIC WEBS AND MAPS

A semantic web or map is a graphic display of the relationship between major and minor ideas. A basic web consists of a core question, and a network of nodes or strands when, which taken together, display the relationship of the whole to the parts, and the parts to the whole.

The use of semantic webbing with students having reading and writing difficulties will:

- serve as a graphic advance organizer and assist students to process new information they read
- help to structure discussion
- assist students to organize and integrate information.

The teacher may use webbing as a diagnostic tool. It is useful in determining:

- the information students derive from material they read
- the students' understanding of categories and relationships.

The semantic webbing strategy can be used as:

- a pre–reading activity:
  - students can brainstorm and make predictions about the reading
  - an advance organizer to introduce new/difficult vocabulary. The web or map may be constructed on the chalkboard and partially completed prior to the activity.

- an activity during reading:
  - the teacher partially constructs a descriptive/narrative/expository web and distributes this to the students. The students complete the web as they read, verifying from the text reasons for their selections. As they locate explicit and implicit text clues, these are written in the boxed nodes or strands.

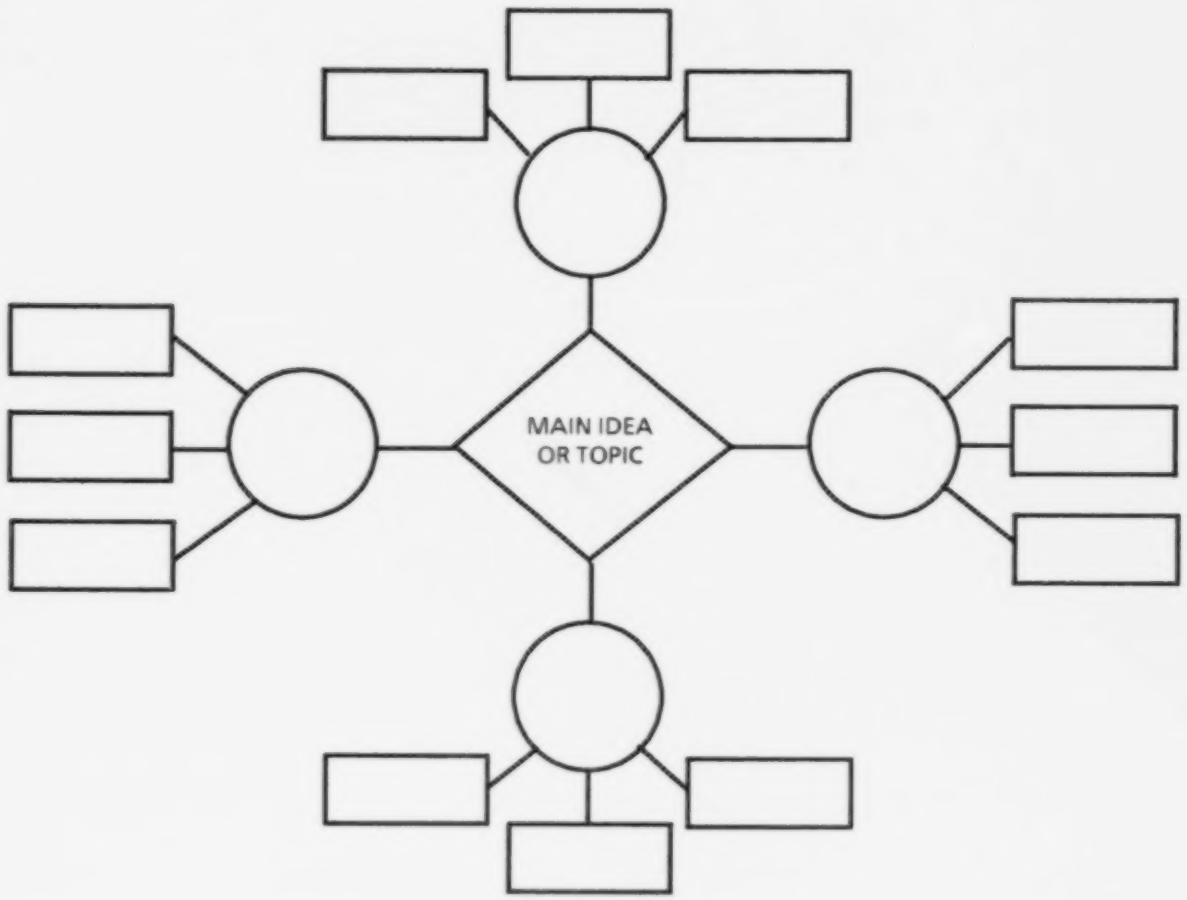
- an activity after reading:
  - students can modify/correct a pre-reading web to verify and extend their knowledge.

- a pre–writing planning activity:
  - students may use a semantic web to organize ideas used in a writing assignment.

The purpose of the activity will determine when and how semantic webbing strategies are used. The pages that follow provide examples of:

- a descriptive or thematic web
- a narrative sequential map
- a comparative and contrastive web.

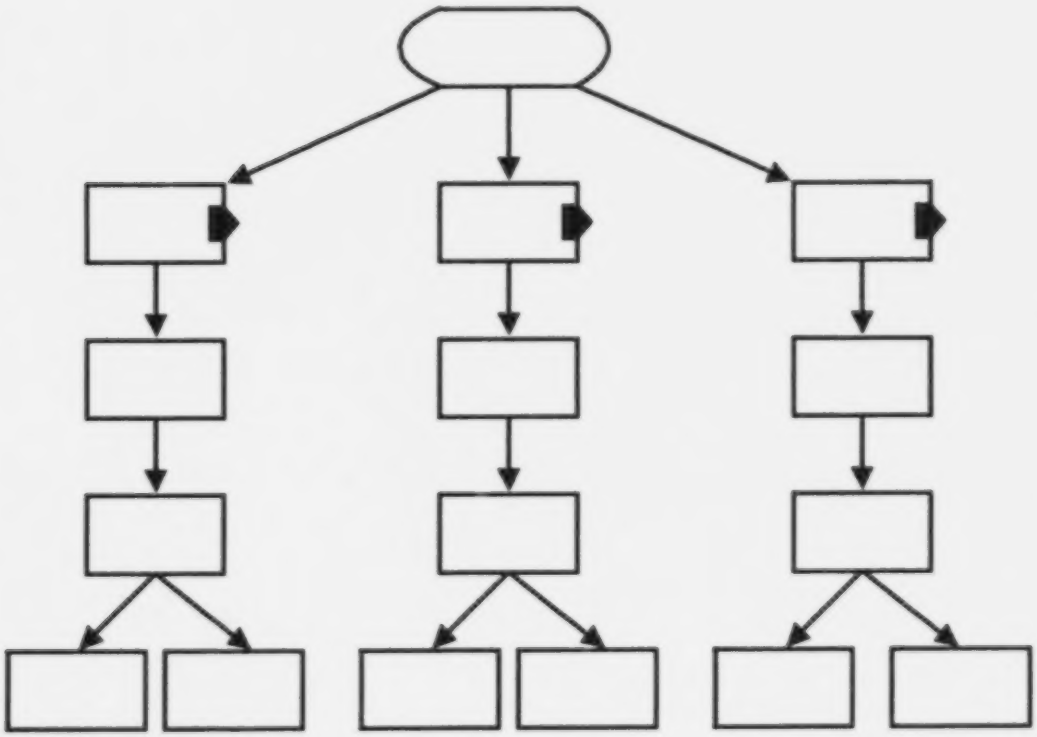
A DESCRIPTIVE OR THEMATIC WEB



RESOURCE 5: USING ADVANCE ORGANIZERS/CONCEPTUAL OVERVIEWS (continued)

A NARRATIVE SEQUENTIAL MAP

(time order)



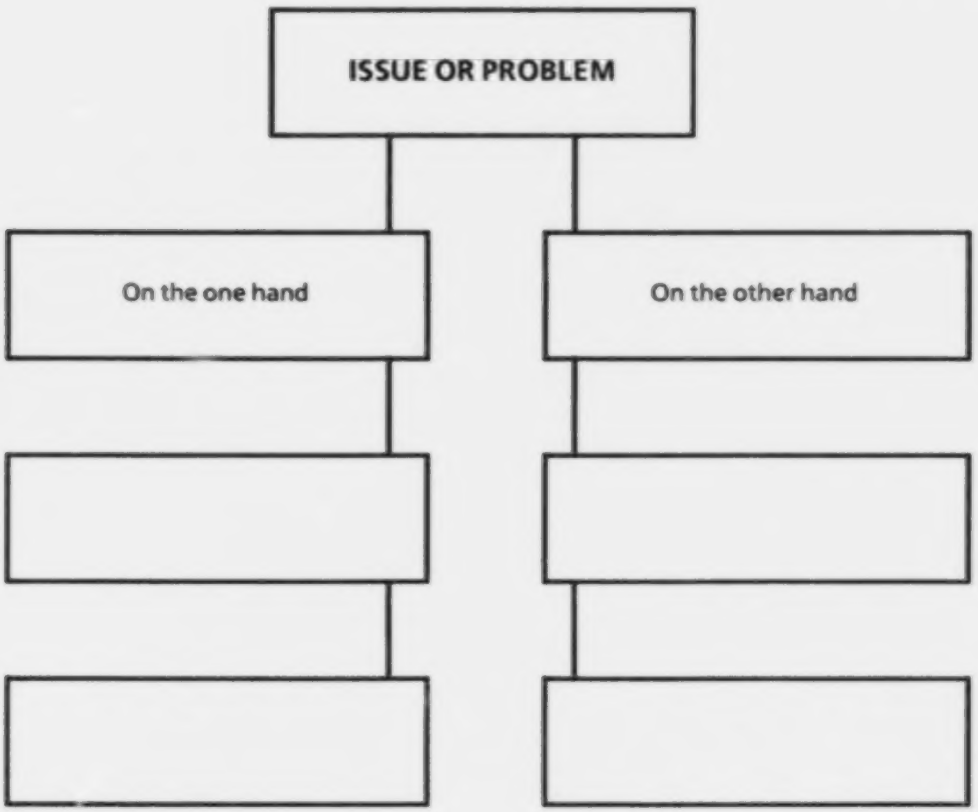
This "map" configuration may be used to visually display:

- the steps in following instructions (e.g., following directions for an experiment)
- the chronological order of a sequence of events (e.g., explaining the operation of a technological device).

This is one of the simpler semantic web configurations and may be used effectively beginning in Grade 8. Teachers may wish to revise this web according to the difficulty of the activity or complexity of the sequence of events (e.g., the bottom six figures may be removed).

RESOURCE 5: USING ADVANCE ORGANIZERS/CONCEPTUAL OVERVIEWS (continued)

A COMPARATIVE AND CONTRASTIVE WEB



CONCEPT CIRCLES[1]

Students can be encouraged to organize and identify relationships among concepts they study through the use of concept circles. Examples that demonstrate what a concept circle diagram looks like are provided on the following page. The steps that follow represent a strategy for drawing concept circles:

1. Let a circle represent any science concept.

2. Print the name of that concept (e.g., plant, temperature) inside the circle.

3. When you want to show that one concept is included within another concept (e.g., all birds are vertebrates), draw a smaller circle within a larger circle. Label the smaller circle by printing the name of the narrower, more specific concept within it. Label the larger circle by printing the name of the broader, more general concept within it.

4. When you want to show that some instances of one concept are part of another concept (e.g., water contains minerals), draw partially overlapping circles. If you want to show that one of the concepts is more inclusive (e.g., broader) than the other, use a larger circle for that one. Label each circle.

5. When you want to show that two concepts are not related (e.g., no crustacean is a vertebrate), draw separate circles and label each one.

6. You may use up to five concept circles in your diagram. They can be separate, overlapping, included, or superimposed. Label each one.

7. The relative sizes of the circles in your diagram can show the level of specificity for each concept. Bigger circles can be used for more general concepts.

8. Coloured pens, markers, pencils or highlighters may be used to colour your concept circle diagram in order to make the relationships between concepts easier to visualize, understand and recall.

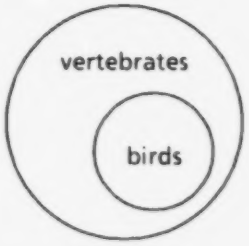
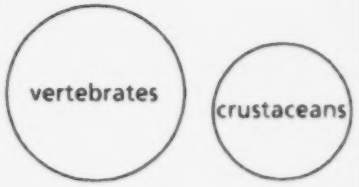
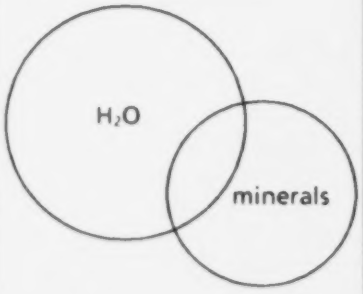
9. When the concept circle is finished, a title describing it should be written in the upper left-hand corner of the page and a sentence that summarizes what the diagram shows should be written in the area directly beneath the diagram.

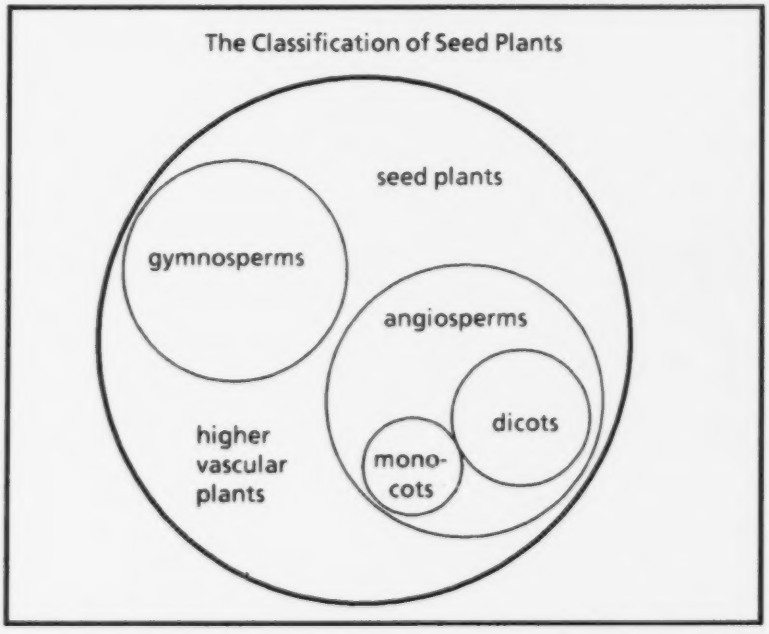
---

1. From *Drawing Concept Circles: A New Way to Teach and Test Students* by James H. Wandersee. Copyright 1987 by James H. Wandersee. Adapted by permission of the author.

RESOURCE 5: USING ADVANCE ORGANIZERS/CONCEPTUAL OVERVIEWS (continued)

SAMPLE CONCEPT CIRCLES

		
Once concept is included within another concept.	Two concepts that are not related.	One concept is part of another concept in some, but not all instances.



RESOURCE 6: MAKING SUMMARIES

USING OUTLINES AND IDEA DIAGRAMS

Outlines similar to the one illustrated below may aid students in organizing their thoughts during the pre-writing phase of a writing assignment, or in summarizing material that has been studied.

Title

I. Main Idea _____

A. fact/supporting detail _____

B. fact _____

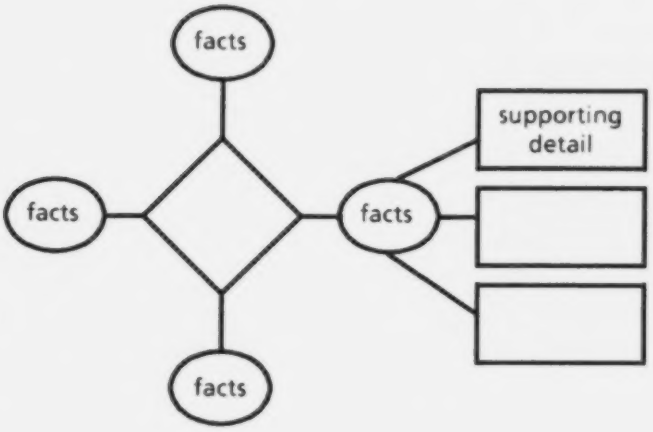
II. _____

A. _____

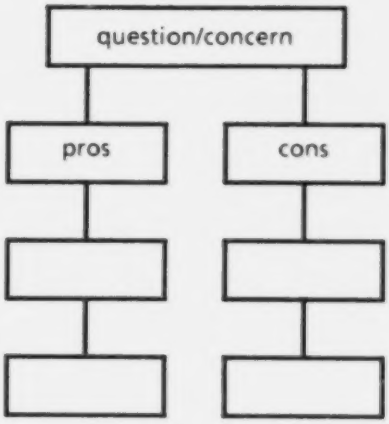
B. _____

Idea diagrams (e.g., semantic webs/maps, comparative/contrastive maps) can also be used in summarizing and pre-writing activities. Two simple configurations are offered as examples.

SEMANTIC WEB/DESCRIPTIVE MAP



COMPARATIVE AND CONTRASTIVE MAP



EVALUATION GUIDE FOR SUMMARIZING[1]

Your summary will be marked on the basis of three criteria:

- identification of the main topic
- identification of other details that are relevant, and
- classification of the details to the main ideas and in relation to each other.

Your assignment will be scored out of 20 marks. The scale at the bottom of the page will help you interpret your score.

	Possible Score	My Score
1. Did you correctly identify the main topic? Did you present it clearly and briefly?	5	
2. Did you include all the important sub-headings? Are they of equal importance?	5	
3. Did you relate other relevant information to each appropriate subheading? Have you omitted any important information? Have you included any unimportant information?	5	
4. Did you use an appropriate semantic web or skeletal outline?	3	
5. Is the overall organization of your notes easy to follow and understand?	2	
TOTAL	20	

Scale Point

One The summary is incomplete. It fails to include most relevant information. The summary scores zero to five points.

Two There are serious omissions of subheadings or there is a failure to include information below the subheadings. Information may be presented at an inappropriate level. The summary scores six to 10 points.

Three Generally, main topic and most subheadings are present but there may be several omissions of relevant details. There may be some inconsistencies. The summary scores 11 to 15 points.

Four The main topic is correctly identified. No more than one major subheading is omitted. Most relevant information is included. The summary scores 16 to 20 points.

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RESOURCE 7: USING CRITICAL THINKING SKILLS

de BONO'S TOOLS FOR TEACHING THINKING[1]

> "Thinking is a skill, and like a skill, it can be developed and improved if one knows how."
>
> – Edward de Bono

There are many proponents of direct teaching of thinking as a skill and Edward de Bono is among the internationally recognized authorities in the field. He proposes a "tools method" whereby techniques for guiding the thinking processes are taught as discrete skills, practised in elementary contexts and later applied spontaneously and independently to real problems. The real life problems may change, but the tools to solve those problems remain applicable. A list of thinking tools follows.

PMI Tool This tool reminds the thinker to first direct his or her attention to the **Plus** points, then to the **Minus** points and finally to the **Interesting** points of a new idea. The thinker is encouraged to make an honest and thorough search in each direction to complete the thinking process relative to the problem.

Example:
What would happen if the two holiday months were July and January?

Plus	Minus	Interesting
• winter ski holiday	• indoors during warm months • dangerous travel	• new types of family holidays
• increase in types of winter recreation	• more travel during potentially dangerous winter months	• studying, concentrating on school during August

Applied to real life problem-solving situations, a PMI can be done to clarify and help arrive at answers to such questions as:

- Should I complete my homework or go to the hockey game?
- Should I attend the dance when parents would be unhappy with my decision?
- Should I lend a friend my new sweater?

C and S (Consequences and Sequels):

- listing the immediate, short-term and long-term effects of a choice to help make a decision.

Immediate Consequence	Short Term Consequence	Long Term Consequence

CAF (Consider All Factors):

- brainstorming and listing everything that needs to be considered in thinking about a problem, formulating a plan, organizing the input and making a decision.

CAF

FIP (First Important Priorities)

- making and examining a list and priorizing items in the list.

FIP

AGO (Aims, Goals, Objectives)

- developing an action plan and/or making a decision by examining the desired outcomes.

AGO

APC (Alternatives, Possibilities, Choices)

- searching for alternatives and extending beyond the obvious in order to consider other possibilities and choices.

APC

OPV (Other People's View)

- collecting, examining and considering the views of others.

OPV

When using deBono's critical thinking tools, teachers are encouraged to:

- make use of key visuals (i.e., charts, lists) to store information and act as a permanent external memory in the problem-solving process
- provide opportunities for practice using these tools in meaningful and novel problem-solving contexts to promote transfer and spontaneous use
- discuss with students the tool which would be most appropriate to use for a particular problem and have them substantiate the reason for their choice.

1. de Bono, Edward. "The Practical Teaching of Thinking Using the CoRT Method", Special Services in the School, Vol. 3 No. 1/2, Fall/Winter 1986, pp. 33-47.

A CRITICAL THINKING WORKSHEET

Choose a topic/issue that you would like to critically examine. Following the steps of critical thinking outlined below, examine the topic/issue and record the results of your analysis.

SOME STEPS FOR CRITICAL THINKING

1. Choose a topic/issue to examine: _____

   _____

2. Ask questions about the topic/issue:

   (a) What are the positive characteristics of this topic/issue? _____

   _____

   _____

   (b) What are the negative characteristics? _____

   _____

   _____

3. Gather additional information as required. _____

   _____

   _____

4. Review the information. (Are there more positive than negative characteristics? More negative than positive characteristics?) _____

   _____

   _____

5. How will you react to this issue? _____

   _____

   _____

RESOURCE 8: GIVING AND FOLLOWING DIRECTIONS

Directions vary in terms of their level of difficulty. The directions outlined below have been categorized according to their level of difficulty.

EASY

- following sewing patterns
- taking medicine
- following traffic directives
- preparing packaged foods (e.g., TV dinners, macaroni dinners)
- heeding warning signals on equipment (e.g., oil light in car)

MEDIUM →

- following recipes
- building a model
- following laundering instructions
- operating common household appliances (e.g., oven timer, vacuum cleaner)
- following rules for board games (e.g., Monopoly, Clue)
- maintaining and using sports equipment (e.g., bikes)
- operating equipment from a rental shop (e.g., carpet cleaner)
- using household chemicals and cleaners (e.g., oven cleaner, drain cleaner)

DIFFICULT →

- assembling furniture
- operating electronic equipment (e.g., VCR, stereo)
- filling out government forms
- maintaining major home appliances/equipment (e.g., furnace)

ACTIVITIES

1. Ask students to identify directions that they must follow in science class. Categorize these directions as easy, medium or difficult.

2. Ask students to identify the components of good directions, and strategies that will help them to give and to follow directions in an appropriate manner..

3. Provide opportunities for students to describe the safety risks involved in giving poor instructions or not following instructions precisely in laboratory situations.

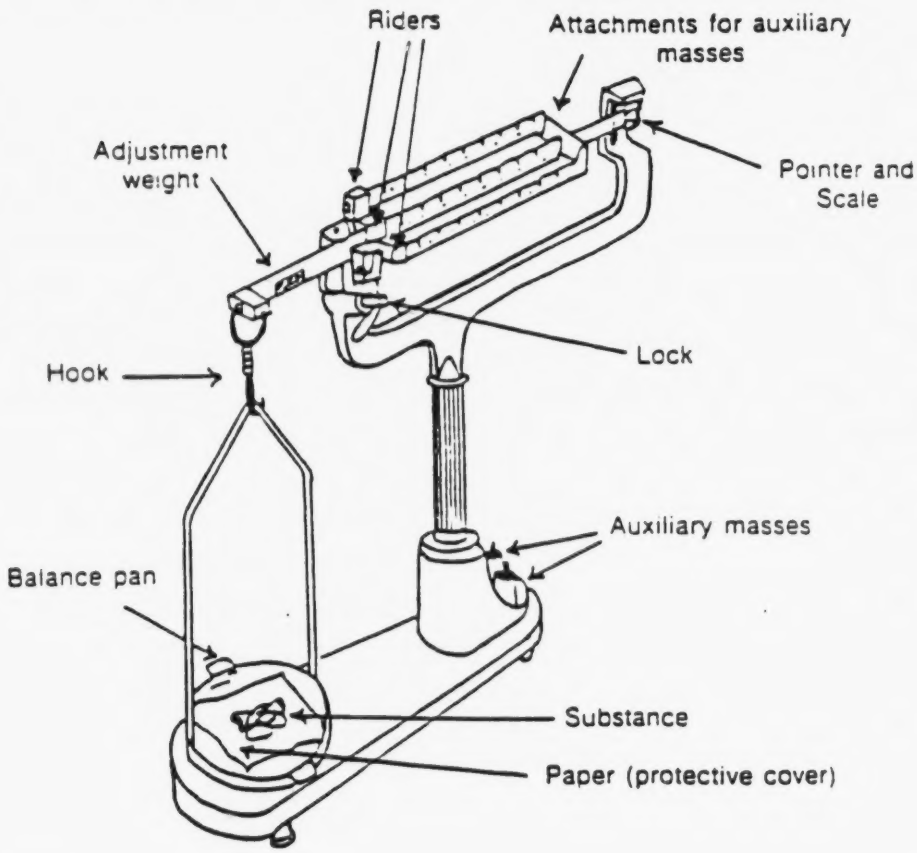
4. Identify self-monitoring strategies that can be used when giving directions to someone else (e.g., asking the receiver questions in order to determine if directions are understood).

5. Invite appropriate community members to attend a class and explain directions that they follow in performing routine tasks at home or at work. These tasks might relate to:
   - changing oil in a vehicle
   - repairing a mechanical/electrical device
   - using a special purpose tool
   - caring for a pet
   - using a chemical product.

WRITING DIRECTIONS[1]

SITUATION

Imagine that it is September 1st, and you have just arrived in science class. Your new lab partner has never been able to use a triple beam balance correctly and is always asking you to do it. You are fed up with doing all the lab work, so you decide to write an excellent set of directions on how to properly determine the mass of an object using a triple beam balance.



ASSIGNMENT

Write a clear set of directions for your partner. If you ask, your teacher will provide you with a balance. When you have written the directions, examine the evaluation guide provided and revise your directions.

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AN EVALUATION GUIDE FOR WRITING DIRECTIONS[2]

The marking criteria listed below will be used to measure your ability to write directions for laboratory procedures. Score your assignment to the maximum number shown on the right of each statement.

	Possible Score	My Score
1. The **title** is present and gives an indication of the purpose of the directions. An example might be, "How to Fly a Kite".	2	
2. **Supplies** and **equipment** are all identified and correctly classified.	2	
3. The **instructions** are listed:		
• in complete sentences	3	
• in the correct sequence	4	
• without any omissions	4	
• in a numbered order	2	
• using present tense	2	
• without addressing 'you'.	1	
4. **Safety hazards**, if they exist, are identified and noted in the appropriate location.	2	
5. The **overall organization** is easy to follow.	*3 or 5	
Total	25	

* Score 3 if identification of safety hazards is necessary and 5 if it is not.

Scale Point

One The directions are incomplete and/or in an inappropriate format. The directions obtain zero to 10 points.

Two There are serious problems with format and there may be omissions. The directions obtain 11 to 15 points.

Three The instructions are logical although there may be some weaknesses in format. The directions obtain 16 to 19 points.

Four A clear set of directions is presented in a standard format. The directions obtain 20 to 25 points.

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RESOURCE 9: STRATEGIES FOR DISCUSSING AND DEBATING

PREPARING FOR GROUP DISCUSSION

Many science activities centre around discussion groups and provide opportunities for verbal communication among students. Students may lack experience in the give-and-take of discussion groups. Some direct teaching of discussion skills may prove useful.

SETTING RULES

Members of the discussion group may increase their involvement if they feel they have some ownership of the rules. Have student generate discussion rules and post these as reminders. Rules may change according to the goals of the group, but ensure that everyone understands the rules.

GROUP SIZE AND SEATING ARRANGEMENTS

Groups of five are ideally suited to discussion. A circle formation permits all members to participate equally.

DECISION MAKING

Reinforce the process by which decisions will be made: consensus, majority vote, compromise, expert or authority in the group. The strongest decisions are those arrived at by group consensus, yet consensus is often difficult to achieve.

MEMBERS' ROLES

Students may require assistance in determining their roles and functions in the group (e.g., a recorder takes notes, a chairperson keeps the topic on track and encourages all members to get involved). The natural leader of the group may need assistance to avoid replacing the "appointed leader".

GROUP GOALS

Remind students of the specific goal of the group discussion and teach them strategies for keeping the discussion directed at reaching the goal (e.g., calling attention to and recording major ideas).

GROUP PROCESS SKILLS

Students may require assistance in developing the following group process skills:

- asking probing questions
- intervening when a member becomes disruptive
- calling attention to major ideas
- keeping time
- remaining on topic
- asking for opinions/information/suggestions from others
- offering opinions, information and suggestions
- correcting others
- asking for clarification
- releasing tension in the group

CHECKLIST FOR SELF-EVALUATION IN GROUP DISCUSSIONS

The following checklist can be used to evaluate personal participation in group discussions. Take a few minutes to reflect honestly on your contribution to the class. Put a check next to those statements that are true of you in today's discussion and fill in the blank spaces appropriately.

1. ___ I contributed ideas without waiting to be asked.
   One idea I contributed was _____

   _____.
2. ___ I kept my remarks on topic.
3. ___ I supported my ideas and remarks with specific details (e.g., I gave an example).
4. ___ I listened carefully and thoughtfully.
5. ___ I can recall other group members' ideas.
   One important idea was _____

   _____.
6. ___ I encouraged other group members to tell more about their ideas.
7. ___ I asked other group members questions about their ideas.
8. ___ I respected other members ideas and opinions even if I disagreed.
9. ___ I let other members finish speaking without interrupting.
10. ___ I changed my mind about something as a result of listening to other members' opinions.
    I changed my mind about _____

    _____.
11. ___ I think I might have made someone else change their mind about something as a result of an idea I contributed.
    The issue was _____

    _____.
12. ___ I have a clearer picture of my own concerns/problems as a result of this group discussion.
13. ___ I have a better understanding of other people's concerns/problems as a result of this group discussion.
14. ___ Here is something I learned from today's discussion: _____

FORMAL AND INFORMAL DEBATES

Debating is a good technique to use to get students to think carefully through complex issues. While debates can take many forms, the following procedures have proven particularly effective in the classroom.

INFORMAL DEBATE

The class will form two teams – one in support of and one against the debate statement. The teams should be seated facing one another.

Arguments are presented by a team member from one side, then a team member from the other side. Arguments are presented alternately until all students have had an opportunity to speak. Each speaker will be allowed one minute. (A person should be selected to be timekeeper.)

This debate should be a spontaneous activity. Teams should not prepare in advance but try to develop the arguments as the debate progresses. Each student will need to listen carefully to the arguments that are presented and introduce his or her own new idea. The object is to try to think and organize ideas quickly. It is almost like brainstorming where someone presents an idea and that idea leads to another idea. Each debater can build his or her idea from the previous idea or present a totally different idea.

After all arguments have been presented, the class will then discuss some of the main points that were brought out by each side. What were the best arguments presented by each team?

FORMAL DEBATE

Organization

Judges

A minimum of three members of the class should serve as judges (or preferably, invite three persons from outside the class). One of the judges must serve as timekeeper and monitor the length of each of the presentations. A second judge should act as the Presiding Judge and supervise the proceedings. He or she will be responsible for keeping the debate orderly and calling on the presenters in turn.

Teams

After the judges have been selected, the remainder of the class should form two equal teams -- one supporting the debate statement and the other opposing the statement. Each team should elect a coordinator whose responsibility will be to organize the team members. The recorder will take notes on the group's activities and decisions. The recorder and coordinator may be the same person, depending on the size of the task.

Preparing for the Debate

Team members will meet to develop the arguments for their position. Each team will first make a list of the major arguments (abbreviated statements) supporting its position. The coordinator will review the list to make sure that all the important arguments have been included and no argument is duplicated. There should be as many arguments as there are team members. If there are too many, the least important should be eliminated. If there are too few, additional ones should be developed.

Make two copies of your team's list and exchange one copy for the list from the other team.

Each team member will select an argument from his or her own list to develop into a short, two- to three-minute defense. He or she will also select an argument from the list submitted by the other team and prepare a two- to three-minute rebuttal (counter argument). Each person will thus be responsible for two arguments: one that supports his or her team's position and the other that answers/attacks the other team's arguments.

The Debate

The debaters make their presentations in the following order:
3 min. – Team 1 presents argument
3 min. – Team 2 presents rebuttal
3 min. – Team 2 presents argument
3 min. – Team 1 presents rebuttal.

The sequence is repeated until all debaters have presented their arguments and rebuttals. A five-minute summation speech is then given by a member (usually the coordinator) from each team. This summation reiterates the most important points made by the team members.

Judging

A convenient method for judging the debate is to evaluate each set of arguments in turn. After each argument and counter argument is presented, the judges will determine which one of the debaters delivered the most effective and convincing argument. Each judge will set up a score sheet similar to that shown below and assign points as follows:

SCORE SHEET

	Team 1 (Pro)	Team 2 (Con)
Argument 1		
Argument 2		
Argument 3		
Argument 4		
Total Points		

4 points = excellent 3 points = good 2 points = fair 1 point = poor

DEBATING POINTERS

The following tips may be helpful to your students in their preparation for and presentation of a debate argument.

- Skillful debating is skillful communication. Make sure your argument is clearly stated and well supported by evidence.
- Explain why your argument is important. This is best conveyed by presenting examples of possible effects.
- Present the argument in a logical sequence, making the most important points first and backing them with sound evidence.
- Speak clearly and slowly so that your argument can be followed by all listeners.
- Be forceful and imaginative. Concentrate on conveying the main issues of your argument.

RESOURCE 10: INFORMAL ESSAY WRITING

WRITING AN INFORMAL ESSAY[1]

SITUATION

Each month we read of the health hazards and environmental damage caused by improper handling of chemicals: the train derailment at Mississauga, Ontario; the spillage of chlorine gas on Main Street in Vancouver; and the use of urea formaldehyde foam as household insulation, are three recent examples.

ASSIGNMENT

Locate a newspaper article that describes the hazards associated with an environmental issue. After considering both sides of the issue, write a letter in which you state your opinion on the matter, the reasons for it, and your recommendations. Your letter should not exceed 250 words. Send your letter to an appropriate government official.

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AN EVALUATION GUIDE FOR INFORMAL ESSAY WRITING[2]

Your assignment will be marked on the basis of two criteria.

- A clear statement of opinion is made.
- Supporting statement. Supply evidence for your opinion by relating an incident, giving an example, or explaining relevant information.

Scale Point

One No opinion is stated. The essay or letter is not on topic.

Two Opinion is offered but with little or no relevant support.

Three Opinion(s) is stated with support, but the essay or letter loses effectiveness because supporting statements are wordy, trite, or over-generalized.

Four The opinion(s) is stated clearly and concisely. The type of data selected is especially convincing; generally more than three pieces are provided.

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EVALUATION

The goal of science education during the 1980's, as stated by the National Science Teachers' Association, is to develop scientifically literate individuals who understand how science, technology and society influence one another and who are able to use this knowledge in their everyday decision making. Furthermore, the 1984 Science Council of Canada report, *Science for Every Student*, offers these recommendations:

- science education must provide a more accurate view of the practice, uses and limitations of science
- science education must include study of how science, technology and society interact
- students must be taught how Canadians have contributed to science and how science has affected Canadian society
- teachers and curriculum planners must evaluate students' progress in all the goals of science education, not just their learning of scientific content.

These recommendations have formed the foundation for the goals of I.O.P. Science 8 and 9. Evaluation practices and techniques must provide feedback and evidence of progress toward these instructional goals. A singular assessment technique cannot provide this evidence. Assessment must go beyond determining the percent of correct responses on a test based on scientific facts, and needs to reflect:

- how students approach "doing" science
- interactions among science, technology and society
- the application of science in real life situations.

Furthermore, it is important to understand that through the process of evaluation we evaluate students' **performance** and not students themselves. This understanding helps one avoid permanently classifying a student as a good student or a poor student. Performance can and does change, and the teacher should be alert to significant changes.

Evaluation strategies have been included in this section of the manual and include:

- Observation
- Interviews
- Inventories/Checklists
- Anecdotal Records
- Individual and Group Projects
- Written Assignments
  - Laboratory Write-Ups and Reports
  - Diagnostic Writing Assignments
  - Paper-and-Pencil Tests.

These strategies should not be used in isolation of one another, and may be combined with other effective strategies. For example, a checklist may be used to document desirable problem-solving behaviour in the classroom, or to guide discussion and evaluate performance in an interview. Teachers are encouraged to expand their application of these evaluation strategies beyond the suggestions/examples provided in this manual.

OBSERVATION

Teachers observe all the time. When observations are documented, their effectiveness as an evaluation strategy increases immensely. Documented observations often provide the raw data required for analysis and diagnosis, and provide the basis on which to make remediation or enrichment decisions.

Science lessons usually have a component in which students work on assignments and projects individually or in small groups. At this time teachers can observe students at work, looking for specific behaviours or outcomes, asking questions and making suggestions. Elements of the learning process that might be monitored through observation include:

- understanding of concepts/skills
- method of attacking problems
- work habits
- level of independence with work
- interpersonal skills and social growth.

Documentation of behaviours that are observed may occur in the form of anecdotal records or checklists. File anecdotal records and checklists in a student folder where samples of daily work, project reports and other artifacts are also placed.

CLARIFICATION/EXAMPLE

Anecdotal Record

Name	Date	Situation	Behaviour	Comment
Nitan	1/17	investigation of electromagnetism, variables affecting strength of the electromagnet	quick to help neighbouring students	understands basic concepts of electromagnetism
	1/25	researching/reporting local methods of producing electrical energy	unable to organize and communicate information gathered	use more pre-writing activities (e.g., semantic mapping, topical outlines)

A sample checklist that might be used in observing student behaviours has been provided as Resource 1: Observational Checklist of Student Behaviours.

Sometimes audiotapes or videotapes can be used to provide records that can be analyzed in more detail at a later time. Photographs are also useful in providing a record of project work. In addition to providing the tangible kinds of things that parents like to see at conference time, these records of student performance enable the teacher to measure progress with more objectivity than simply through memory of what was done.

INTERVIEWS

A planned interview with a student or group of students is an effective technique for assessing knowledge, understanding, thinking style, attitude or personal interests. An interview removes the restriction of writing, and enables the teacher to delve more deeply into a student's thought patterns and how he or she goes about finding an answer or solving a problem. Although written responses on an assignment may indicate areas of concern, more information is often required before appropriate remediation can be provided. Remediation strategies that are based solely upon the analysis of written responses may in fact be inappropriate at times. Holding interviews with students can reveal both unsuspected weaknesses and surprising strengths in their understanding of scientific thought processes.

Some guidelines for conducting interviews include:

- Establish an atmosphere of acceptance. The student must feel comfortable enough to verbalize his or her ideas freely. By accepting the student's responses without judgement, but with encouragement to elaborate further, you are communicating not only respect for the student's thinking but also a curiosity to learn more. Each response, whether right or wrong, has the potential of providing information about the student's level of understanding.

- Ask probing questions. During the interview, ask questions and introduce materials that will cause the student to extend and apply concepts/skills to new areas. Rephrase questions using vocabulary familiar to the student, so as to clarify both your intent and the student's thinking. Although some of the questions you ask should be planned, others should be invented spontaneously in order to test your hunches about the student's thinking. Questions asked may take some of the following forms:
  - How did you . . .?
  - Why did you . . .?
  - How do you know that . . .?
  - Tell me more about . . .
  - What else might happen if . . .?
  - Can you describe . . .?
  - What made you ask that question?
  - How do you feel about . . .?

- Pace the interview appropriately. By allowing an adequate pause following each question before repeating or rephrasing it, you are giving the student time to interpret the question and construct the response. On some tasks, the student may need more than a thirty-second pause, whereas on others, three seconds will suffice. Also, by allowing an adequate pause following the student's response, you are indirectly encouraging him or her to elaborate on his or her initial response.

- Be prepared to coax and encourage the student to make a response. A frequent response given by the student may be "I don't know" or "I forget". Sometimes an extended pause can coax out productive thinking. At other times, the teacher can encourage a response to questions about which the student is unsure by saying:
  - "I know it's not easy to think about. Just give me your best idea."
  - "Pretend that you know. How do you think it might be done?"

Interviews should have a definite purpose and both teacher and student should be aware of the purpose. Interviews must be planned in advance. In preparing for an interview, the teacher should consider:

- What questions will I ask?
- What basic understandings will I initially assess?
- How can I incorporate the use of manipulative materials?
- How can I vary the task and questions to obtain different perspectives on the student's ability?

Maximum benefits can be gained from an interview by reflecting on your interaction after listening to an audiotape playback. Considerable value can also be gained from sharing your tape with a colleague. By discovering how students interpret and view a problem, the teacher will be better able to make effective on-the-spot decisions in the classroom.

Several guides for interviewing have been included at the end of this section of the manual:

- Resource 2: Gaining Information From Text
- Resource 3: Interview Guide for Inquiry/Problem Solving
- Resource 4: Interview Guide for Project Work.

INVENTORIES/CHECKLISTS

Inventories and checklists are documentation strategies that can be used conjunctively with other evaluation strategies. They can be easily designed and customized to meet many different needs and situations. Generally a matrix is created, with indicators of desirable behaviours/outcomes on one side, and ratings/skill levels along another side. As teachers note a particular behaviour, they need only check the appropriate column that evaluates or rates the behaviour.

Checklists lend themselves very well to documenting such elements of the program as:

- comprehension of a concept
- mastered knowledge, skills or process
- work habits
- use of inquiry/problem-solving/decision-making strategies
- social skills.

CLARIFICATION/EXAMPLE

Checklist/Inventory of Social Skills

Behaviour to be Observed	Frequently	Sometimes	Never
Is sensitive to the needs and problems of others.			
Willingly shares ideas/materials.			
Accepts suggestions and help.			
Listens while others speak.			
Adheres to group plans/decisions.			
Works cooperatively with others.			
Considers the viewpoints of others.			
Respects the property of others.			
Appears to like group work.			
Speaks clearly/expresses ideas clearly.			

Checklists and inventories that may be useful in documenting certain elements of the science program are provided at the end of this section, and include:

- Resource 5: Inventory of Inquiry Skills/Attitudes
- Resource 6: Checklist for Assessing Writing Assignments.

Similar checklists can be developed to monitor and evaluate other components of the science program.

e.g., – comprehension of concepts
– use of problem-solving and decision-making strategies.

ANECDOTAL RECORDS

Anecdotal records refer to the spontaneous documentation of notable behaviour, effort and achievement. These records provide specific and dated information that can form the basis for conclusions and assessments. Anecdotal records often prove invaluable in clarifying assessments and add credibility to observations and recommendations being offered in student, parent and/or teacher meetings.

Anecdotal records may include observations on:

- attitude/work habits
- social skills
- effort and homework
- changes in performance
- specific strengths/deficiencies
- communication skills.

CLARIFICATION/EXAMPLE

Anecdotal Record Card

Student: Sue Jones Date: 04/10

Comments:

- demonstrates an understanding of concepts studied through questions that she asks
- follows directions accurately, but is unable to establish/plan her own procedures for an investigation
- shows interest in helping others, excellent group worker
- has difficulty in selecting laboratory apparatus that is appropriate to a particular task

Anecdotal records may be kept in a daily or weekly diary, in student files, in the marks record book, or in a common file of short, dated notes.

INDIVIDUAL AND GROUP PROJECTS

Individual and group projects provide opportunities for students to demonstrate their ability to use a variety of skills through activities that may involve research in the library/community, experimental work in the laboratory, or combinations of these and other activities. Students usually enjoy project work as it provides them an opportunity to direct their own learning. Teachers should be prepared to assist students in planning their projects, and in obtaining information, materials and equipment that may be required.

The quality of student work will be improved if students understand the criteria on which their projects will be evaluated. Teachers may wish to evaluate students in terms of their ability to:

- plan and design the project
- use appropriate processes/skills.

CLARIFICATION/EXAMPLE

Criteria for Evaluating a Plan/Design

Criteria	Score
Devises a good plan for research/investigation. Plan is clear, concise and complete.	9 – 10
Devises a plan for research/investigation that needs some modification. Understands the overall approach.	7 – 8
Devises an acceptable plan for research/investigation with some help.	5 – 6
Devises an inappropriate plan for research/investigation that needs considerable modification. Does not understand purpose/overall approach.	3 – 4
Has little idea of how to plan for research/investigation. Must be directed through each step.	1 – 2

CLARIFICATION/EXAMPLE

Criteria for Evaluating Process and Skill

Criteria	Score
A. Creative Thought	10

Does the project show creative/original thought in:
- questions asked?
- the approach to problem solving?
- the analysis/interpretation of data?
- use of equipment?
- the construction/design of a device or process?

B. Scientific Thought	10

Does the project display an understanding of:
- the purpose/problem?
- a procedural plan?
- variables and controls?
- conclusions that may be drawn from data collected?
- the limitations of data collected?

C. Strategies and Skills	10

Did the student:
- demonstrate knowledge and skill in using necessary equipment?
- use locally available sources of information?
- complete the project with minimal assistance?
- understand and use appropriate technical vocabulary?
- complete the project in a neat and orderly manner?

D. Thoroughness/Clarity	10

Does the project:
- carry out its purpose to completion?
- have appropriate notes/diagrams/illustrations?
- present data clearly and in sequential order?
- explain itself?

Can the student:
- discuss the project?
- explain the purpose, procedure and conclusions in a clear and concise manner?

WRITTEN ASSIGNMENTS

LABORATORY WRITE-UPS AND REPORTS

Students may be asked to demonstrate their understanding of concepts and skills by preparing laboratory write-ups and other written reports. Guidelines for evaluating these kinds of written assignments are provided throughout other sections of this manual, and include:

- An Evaluation Guide for Observation (see The Nature of Science)
- An Evaluation Guide for Summarizing (see Communication Skills)
- An Evaluation Guide for Writing Directions (see Communication Skills)
- An Evaluation Guide for Informal Essay Writing (see Communication Skills).

DIAGNOSTIC WRITING ASSIGNMENTS

Diagnostic writing assignments require students to respond to questions in an expressive writing style. Written responses often force the students to examine their own understanding of concepts and will communicate to teachers how much students really know about a concept. Written responses also provide insight into how the student thinks. These assignments have proven successful as a diagnostic tool. Appropriate remedial and enrichment activities may be determined on the basis of the understanding demonstrated for a given concept.

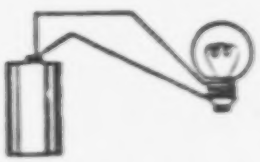
CLARIFICATION/EXAMPLE

Applying Knowledge of Electrical Circuits

Circle the diagram below that represents a closed circuit. Explain why each of the other diagrams do not represent closed circuits, and how you would make the lamp work in each situation.

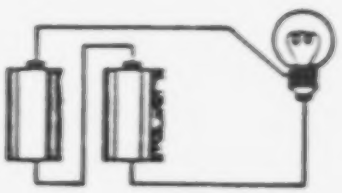
A.

B.



C.

D.



Written assignments at this grade level should be short. They should not be graded for a mark but rather, assessed for understanding (diagnosis). Students might be awarded bonus points based on their effort and presentation.

CLARIFICATION/EXAMPLE

0 points	–	no effort
1 point	–	mediocre attempt with little or no understanding
2 points	–	good attempt, but with some lack of understanding
3 points	–	high level of effort and understanding

Diagnostic writing assignments can be kept in a student diary or logbook, and might be assigned on a regular basis (once or twice a week), or in lieu of a regular quiz.

PAPER-AND-PENCIL TESTS

Traditional paper-and-pencil tests are probably the most widely used method of evaluating student performance. While effective in assessing factual and procedural knowledge, these tests often elicit feelings of inadequacy and self-doubt for students who have experienced previous difficulty or failure. These negative feelings affect test performance, and may cause a cycle of repeated failure to continue.

Students may have learned the information presented in class, but are unable to demonstrate the knowledge because of poor reading skills, visual perception problems, inadequate reasoning and comprehension, fine-motor difficulties or other related deficiencies. Special needs of the student can be met through minor alterations in the construction of teacher-made tests. Constructing tests according to special needs can mean the difference between success and failure of some students.

The suggestions that follow will assist teachers to construct their tests according to the needs of individual students.

TEST DIRECTIONS

- Keep directions simple and avoid unnecessary words.
- Define words that are unfamiliar or abstract.
- Give an example of how the student is to respond whenever possible.
- Avoid oral directions as the only means of communication. Read directions orally as well as clearly writing them on the test.

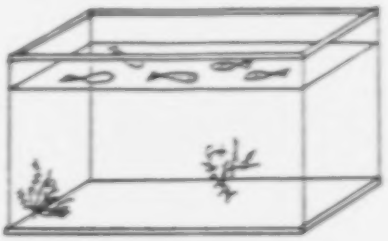
TEST ITEMS

- Provide manipulative materials that make situations more concrete whenever possible.
- Avoid mixing different question formats in the same section of the test.
- Design questions that:
  - are relevant to the students' personal experience
  - consist of simple sentences and familiar words.
- Underline or circle key words in a question.
- Ask students to circle the correct response in multiple choice items. This reduces the possibility of copying errors when transferring letters to blanks. Arrange the answer and distractors vertically on the page.

- Keep all matching items brief, and have only one correct answer for each item. Use no more than ten items in the matching lists. If you have more than ten items, group them by concepts in clusters of ten.
- Provide visual prompts that will assist students to recall and process information.

CLARIFICATION/EXAMPLE

Write two hypotheses you might make on the basis of this picture.



TEST DESIGN

- Construct the test in logical sequential order, from simple to complex problems.
- Use test items that reflect the content taught and techniques used to teach.
- Prepare a study guide for the test that matches the design of the actual test.
- Design the test to reflect the student's knowledge, rather than ability to follow complicated directions, to use difficult vocabulary, or to work under time constraints.
- Adjust the readability level of the test to meet student needs.
- Prepare the test in short sections that can be administered individually if necessary.

RESOURCE I: OBSERVATIONAL CHECKLIST OF STUDENT BEHAVIOURS

LEVEL OF INDEPENDENCE WITH WORK:	ALWAYS	OFTEN	SOMETIMES	NEVER
• Settles down to work upon entering class.				
• Spends time on task; has satisfactory attention span.				
• Takes responsibility for making up work after absences.				
• Takes responsibility for supplies and equipment.				
• Follows directions; completes tasks with minimal assistance.				
• Asks for and accepts help when needed.				
• Accepts a challenge; works productively on tasks of increasing difficulty.				
• Displays self-confidence and pride in work.				

UNDERSTANDING OF CONCEPTS AND SKILLS:				
• Uses the necessary vocabulary and concepts.				
• Uses appropriate operations, strategies and principles.				
• Asks questions, volunteers answers.				
• Answers questions that involve thought (e.g., What do you think?).				
• Demonstrates understanding through ability to generalize and apply.				
• Displays curiosity about objects, events, concepts and relationships.				
• Works independently on projects and research.				

ABILITY TO INVESTIGATE AND SOLVE PROBLEMS:	ALWAYS	OFTEN	SOMETIMES	NEVER
• Understands and defines problems/issues.				
• Develops a systematic plan of attack.				
• Gathers information using a variety of sources.				
• Carries out plans and procedures, seeking help when necessary.				
• Uses appropriate strategies and processes.				
• Considers alternatives before reaching a solution/decision.				
• Evaluates solutions to the problem and decisions made.				
• Considers other ideas/opinions/solutions.				
• Defends personal statements/position on the basis of logical evidence.				

INTERPERSONAL SKILLS AND SOCIAL GROWTH :				
• Resists aggressive and impulsive behaviours.				
• Volunteers to work in group situation.				
• Cooperates and contributes to group goals.				
• Listens to peers; considers the opinions of others.				
• Participates in oral discussions.				
• Willingly helps others.				

RESOURCE 2: GAINING INFORMATION FROM TEXT

Select a chapter of a science textbook. The textbook should be one currently in use in the student's science program.

WORD IDENTIFICATION

Ask the student to read aloud a passage of about 200 words. Note the number of words identified correctly. ____% of words are identified correctly.

If the student identified 90% or more of the words correctly, proceed with the interview. If the student identified less than 90% of the words correctly, select an easier textbook. Hesitations and self-corrections should not be counted as errors.

SURVEY OF STRATEGIES

Ask the student to show you how he/she would study the chapter in order to gain information. Ask him/her to verbalize his/her thoughts during the course of reading. Note the strategies employed by placing a √ in the blank space.

- Skimmed: introduction _____
  headings _____
  figures and illustrations _____
  italics _____
  conclusion _____
  prior to reading the chapter
- Read the chapter from beginning to end _____
- Began to read chapter, then gave up _____
- Spontaneously asked himself/herself questions while reading _____
- Used study questions as a guide for reading _____
- Picked out the main ideas or important points while reading _____
- Paraphrased main ideas or important points _____
- Looked up unknown words in the dictionary _____
- Underlined or highlighted important information _____
- Made notes _____

Other: _____

_____

_____

_____

RESOURCE 2: GAINING INFORMATION FROM TEXT (continued)

PROBES

Some students have strategies in their repertoire that they do not use unless directed to do so. Select a different chapter in the same textbook and rate the student's skill on the following directed procedures.

	Excellent	Adequate	Inadequate	Notes
Getting appropriate information from: introduction headings figures and illustrations italics conclusions Self-questioning Paraphrasing of main ideas Identifying words not understood Looking up words in the dictionary				

Comments: _____

_____

_____

_____

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RESOURCE 3: INTERVIEW GUIDE FOR INQUIRY/PROBLEM SOLVING

1. Establish rapport to help the student feel comfortable.

2. Ask the student to "talk about what he or she is doing or thinking" while conducting an investigation or solving a problem. Explain that this will enable you to help the student to develop effective inquiry/problem-solving strategies.

3. As the student attempts to understand the problem and design procedures, observe the student and ask questions such as the following, if appropriate:

   a. What did you do first when given the problem? Next?
   b. What are the important facts and conditions in this situation? Do you need to obtain additional information that has not been provided?
   c. Is there anything you don't understand about the problem or situation?

4. As the student develops and carries out a plan, remind him or her again to talk about it, and ask questions such as the following, if appropriate:

   a. What do we want to investigate/explain/construct?
   b. What do you think might happen if . . .?
   c. What is the relationship between . . . and . . . ?
   d. What strategy are you using? Have you thought about using other strategies? Which ones?
   e. Where are you having difficulty? What should you do next?

5. As the student proceeds to carry out the plan, observe the ways, if any, in which he or she monitors and evaluates progress. Ask questions such as:

   a. What caused . . . to happen?
   b. What does the data indicate?
   c. Are you sure this is the correct answer to the problem? Why?
   d. Do you think it is important to check your answer? Why?

6. After the student has solved the problem, ask questions such as:

   a. Can you describe your findings/outcomes?
   b. Is this problem like any other problem you've solved? How?
   c. Do you think there are other ways of dealing with this situation? What are your ideas?
   d. How could you make your work easier another time?
   e. How did you feel while you were solving this problem? How do you feel now that you have found a solution?

RESOURCE 4: INTERVIEW GUIDE FOR PROJECT WORK

THE TASK ENVIRONMENT

1. How did you select this investigation/project? _____

   _____ _____

2. Are you interested in it?
   _____ very _____ somewhat _____ not at all

3. What did the teacher do when giving out the assignment? _____

   _____

   Examples:
   - give verbal guidelines
   - give written guidelines
   - select the topic
   - provide a strategy
   - increase your interest

4. Who do you expect will examine the results of your investigation/project? _____

   _____

PREVIOUS KNOWLEDGE

5. Have you undertaken an investigation/project like this before?
   _____ yes _____ no

6. What did you know about this topic before you started? _____

   _____

7. Which of the following scientific processes did you use in carrying out your investigation/project?

   _____ recognizing patterns
   _____ defining problems
   _____ predicting events
   _____ performing experiments
   _____ controlling variables
   _____ taking measurements
   _____ using arithmetic
   _____ making inferences
   _____ making a model
   _____ gathering information
   _____ formulating hypotheses
   _____ making a plan
   _____ collecting data
   _____ making observations
   _____ organizing data
   _____ classifying
   _____ identifying cause/effect
   _____ making decisions

PLANNING

8. How did you plan your investigation/project? _____

   _____

RESOURCE 4: INTERVIEW GUIDE FOR PROJECT WORK (continued)

9. Did you make an outline of the steps you would take?

_____ yes _____ no

What kind of thinking did you do first? _____

_____

10. Did you do any research? _____ yes _____ no

What sources of information did you use? _____

_____

REVIEWING AND APPLYING

11. What strategies did you find most helpful in completing your investigation/project?

Examples:

_____ reading
_____ following directions received
_____ explanations from the teacher
_____ studying diagrams/models
_____ performing experiments
_____ watching films/filmstrips
_____ having a group discussion
_____ listening to a guest speaker
_____ other

12. Explain three ways that you might make use of the results of your investigation in everyday life.

_____

_____

_____

EVALUATING

13. What have you learned in completing this investigation/project? _____

_____

14. What grade did you think you would get? _____

Why? _____

15. What was the teacher's evaluation? _____

How was this evaluation different from your anticipated grade? _____

_____

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RESOURCE 5: INVENTORY OF INQUIRY SKILLS/ATTITUDES

INQUIRY SKILLS:

	Applies Skill Independently	Needs Periodic Assistance	Needs Constant Assistance	Does Not Participate
• Asks questions about natural phenomena				
• Formulates problems/makes hypotheses.				
• Designs/conducts experiments.				
• Makes inferences/predictions.				
• Makes/records accurate observations.				
• Makes comparisons.				
• Uses measurement skills.				
• Classifies objects in a variety of ways.				
• Uses appropriate methods to gather/record information.				
• Interprets tables/charts/graphs.				

INQUIRY ATTITUDES:

	Consistently	Frequently	Occasionally	Rarely
• Shows interest in studying natural phenomena.				
• Demonstrates an objective attitude by considering evidence for and against an idea.				
• Demonstrates curiosity about observations by asking questions and conducting investigations.				
• Demonstrates, through discussion, an understanding of the differences between hypotheses, solutions, facts and inferences.				
• Changes an opinion when confronted with evidence.				
• Appreciates that a correlation does not necessarily mean a cause and effect relationship.				
• Critically examines experimental procedures and outcomes.				

RESOURCE 6: CHECKLIST FOR ASSESSING WRITING ASSIGNMENTS

IDEAS AND ORGANIZATION:	Excellent	Adequate	Inadequate	Not Applicable
• Understands the purpose of the writing activity.				
• Uses an appropriate title.				
• Uses pre-writing activities to plan work.				
• Demonstrates an understanding of content.				
• Chooses and organizational pattern that suits the purpose.				
• Writes a clear/concise topic sentence.				
• Provides supporting details and examples.				
• Expresses ideas in an appropriate sequence.				
• Clarifies ideas by using pictures/charts/diagrams.				
• Concludes assignment by recalling the main points and summarizing.				

EXPRESSION AND MECHANICS:	Excellent	Adequate	Inadequate	Not Applicable
• Uses appropriate vocabulary.				
• Avoids spelling errors.				
• Includes sentence variety.				
• Avoids shifts in personal pronoun use/verb tense.				
• Maintains agreement of person, number and gender in subject and verb.				
• Uses correct punctuation.				
• Completes assignments legibly and neatly.				

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